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MAY 1837.

Practical and Theoretical Mechanics.

Report of the Committee of the Franklin Institute of the State of Pennsylvania on the Explosions of Steam Boilers, of Experiments made at the request of the Treasury Department of the United States. PART II. *Containing the report of the sub-committee to whom was referred the examination of the strength of the materials employed in the construction of Steam Boilers.*

[CONTINUED FROM PAGE 277.]

Piled iron, when manufactured from *blooms*, does not, generally, it is believed, undergo a second hammering after being received at the rolling mill. At the first heat it is reduced to bars an inch or more in thickness, when it is cut up, piled as before mentioned, and rolled into plate.

The practice of *piling* appears to be followed, in some instances, from a supposition that a greater security from flaws and other blemishes, must result from combining the strength of three distinct laminæ—and fortifying the weak points of one by the strong parts of the two others, than could probably be derived from the simple unlaminated sheet, in which any imperfection would, it is supposed, extend through the entire thickness.—But the uncertainty of uniform welding between the members of a pile is sufficient to warrant some hesitation in approving this method. Table XXXIII., at experiments 12 and 13, affords evidence that the structure of this description of boiler iron is sometimes exceedingly imperfect, owing to a want of complete welding between the laminæ of which it is composed.

In a subsequent part of this report, will be found discussions on the relative influence of the different processes above described, and also on the *repetitions of piling* upon tenacity. It will there be seen that the practice of piling or *faggoting* may not in all cases prove detrimental to the iron, but will depend in some measure upon the degree of refining which it has previously undergone,—and its consequent freedom from earthy or other impurities which might interfere with accurate welding, as well as upon the temperature employed for that process. If, after reducing either *refinery blooms* or *puddled balls* to thin bars, fit for piling, there be made a perfect union of surfaces during this operation, the latter has evidently the advantage of affording to the impurities a more ready escape from interior portions of the metal, than would otherwise be obtained.

TABLE XLI.

Experiments on bars No. 81, 83, 84, 90 and 91. Manufactured at the Juniata Iron Works, near Pittsburg, by Messrs. Schoenberger & Son, from blooms by hammering and rolling. These strips were all cut

No. of the bar.	Direction of the slit.	No. of exp's.	DATE.	Length before trial.	Breadth.	Thickness.	Area of the section of fracture before trial.	Temp. Fah.	Breaking wt. in the scale.	Br. wht. X leverage.	Friction.	Effective strain.	Strength in pounds per sq. inch.
81	Cross.	1	1832. April 7.	24.075	.500	.186	.093000	65°	140	4200	210	3990	42904
81	"	2			.444	.182	.080808	65	133	3990	199	3791	46914
81	"	3			.440	.186	.081840	65	150	4500	225	4275	52236
81	"	4			.490	.184	.090160	65	200	6000	300	5700	63221
83	Cross.	5		24.0	1.014	.182	.184548	65	273	8190	409	7781	42162
83	"	6			.936	.184	.172224	65	296	8880	444	8436	48983
83	"	7			.988	.180	.177840	66	353	10590	529	10061	56573
84	Cross.	8		23.8	1.060	.182	.192920	66	289	8670	433	8237	42696
84	"	9		9.00	1.084	.182	.197288	66	319	9570	478	9092	46085
84	"	10		15.2	.990	.178	.176220	66	294	8820	441	8379	47548
90	Cross.	11	April 14.		.533	.247	.131651	600	263	7890	394	7496	56938
90	"	12			.679	.245	.166355	54	263	7890	394	7496	45060
90	"	13			.674	.252	.169848	54	328	9840	492	9348	55037
90	"	14			.608	.240	.145920	54	295	8850	442	8408	57620
90	"	15			.610	.245	.149450	50	270	8100	405	7695	51489
90	"	16			.585	.250	.146250	596	296	8880	444	8436	57682
91	Cross.	17		24.	1.072	.246	.263712	65	392	11760	588	11172	42365

TABLE XLI.

off crosswise of the sheet, and tried either at original or at detached filed sections. Specific gravity 7.7580.

Wts. producing temporary elongation.	Elasticity of the bar.	Length after trial.	Area after trial.	REMARKS.
112 140	36.5′ Broke.		.500×.182 =.091000	This was a narrow strip and broke at an original section.
				do. do. do. do. do. do.
224 273	34. Broke.		1.014×.162 =.174408	The weight recorded was added by 7 lbs. at a time, not supposing the breaking weight to be nearly attained. The bar had borne 266 lbs. without signs of yielding. A filed section had been made .928 inch in breadth, and .180 thick, area 167040.
			.932×.162 =.150984	Broke at an original section.
345 353	10. Broke.		.988×.168 =.157034	The filed section had now been reduced to .904×.170=.153680. The section filed in the first experiment now bore 60231 lbs. per sq. inch without breaking, and calculating on its present area it bore 65467.
168 224 275 289	50. 52. 54. Broke.	24.05	1.046×.162 =.169452	A filed sect. in this bar had an area of .896×.176=.157696. Broke at an original sect. in the middle of the bar.
224 317 319	33. 24. Broke.	9.2	1.020×.160 =.163200	A filed section in the part now under trial has the dimensions .884×.178=.157352. Its strength as indicated by this trial was above 50421 lbs.
280 294	53. Broke.		.974×.160 =.155840	A section had been filed with the dimen..884×.178=.157352, and giving a strength above 56046. Broke at an original section near the wedges.
				Temp. not very accurately noted at the instant of fract., believed to have been as high as numb. recorded. (600.)
				Broke at a filed section.
				The filed sect. not so deep as before. The filing still less than the preceding.
				Much deeper filing than either of the two preceding.
				The w'ht. is approximate only, as the bar broke instantly on applying 270 lbs; which was supposed its full load. Broke in tin at the filed section.
112 224 280 347 364 392	0.50.5′ 1.16. 1.00. 0.34. 0.20.5 Broke.	24.15		Broke at a section not filed.

TABLE XLII.

Experiments on bar No. 88. Manufactured at the Juniata Iron Works, near Pittsburg, by Messrs. Schoenberger & Son, from blooms, by hammering and rolling into boiler-plate. This strip cut off lengthwise of the sheet, and tried after having been reduced to a nearly

Marks.	Breadth.	Thickness.	Area before trial.
0	.741	.219	.162279
1	.767	.219	.167973
2	.767	.222	.170274
3	.767	.223	.171041
4	.766	.220	.168520
5	.767	.221	.169507
6	.764	.221	.168844
7	.771	.220	.169620
8	.768	.219	.168192
9	.769	.220	.169180
10	.767	.222	.170274
11	.765	.222	.169830
12	.769	.223	.171487
13	.769	.221	.169949
14	.770	.218	.167860
15	.769	.221	.169949
16	.768	.222	.170496
17	.771	.221	.170391
18	.767	.220	.168740
19	.767	.221	.169507
20	.780	.228	.177840
Mean of 21			.169611
Maximum			.177840
Minimum			.162279
Mn. of these 2			.170059
Diff. of the 2			.015561

Marks.	Breadth.	Thickness.	Area after trial.
After the 2d fracture, 321 lbs.			
0	.635	.130	.082550
1	.752	.205	.154160
2	.756	.213	.161028
3	.769	.216	.166104
4	.767	.217	.166439
5	.768	.219	.168192
6	.759	.221	.167739
7	.762	.220	.167640
8	.750	.213	.159750
9	.759	.214	.162426
10	.755	.215	.162325
11	.758	.215	.162970
12	.763	.220	.167860
13	.761	.215	.163615
14	.761	.213	.162093
15	.763	.217	.165571
16	.761	.215	.163615
After the 6th fracture, 370 lbs.			
3	.755	.212	.160060
4	.743	.204	.151572
5	.752	.212	.159424
6	.745	.213	.158685
7	.753	.214	.160542
8	.749	.210	.157290
9	.746	.211	.157406
10	.742	.208	.154336

The part from three to ten was, at the time of these measurements, 7.51 inches in length.

DATE.	No. of the experim't.	Area of the section of fracture before trial.	Temperature. Fah.
1832.			
Dec. 22,	1	.170391	610°
"	2	.162912	630
Dec. 29,	3	.169949	55
"	4	.167860	55
"	5	.170658	55
"	6	.170052	55
1833.			
Jan. 3,	7	.170657	61
"	8	.168521	61
"	9	.168520	61
"	10	.169103	61
"	11	.169507	61
Mean of 11 sections		.168921	

TABLE XLII.

uniform size by filing, and gauged at every inch, from 0 *to* 20. *Specific gravity,* 7.7922. *Original size before filing about* 1 *inch by* .25.

Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in lbs. per square inch.	Points of fracture.	REMARKS.
296	8880	444	8436	49509	No. 17	Had been, during the experiment, for a short time as high as 630°. Part in tin from 11½ to 15½.
321	9630	481	9149	56159	" 0½	Part in tin from 4 to 8.
346	10380	519	9861	58024	" 15	
353	10590	529	10061	59937	" 14	
358	10740	537	10203	59786	" 11½	
370	11100	555	10545	62010	" 10½	Slightly griped by the wedges at the section of fracture.
368	11040	552	10488	61457	" 2½	Do.
385	11550	577	10973	65113	" 8½	
385	11550	577	10973	65114	" 4	
383	11490	574	10916	64552	" 6½	
320	9600	480	9120	53803	" 19	Part broken off in the first experiment. The mean area of the 11 sections of fracture is .000690 sq. inch *less* than the mean area of the 21 measured sections.

TABLE XLIII.

Experiments on bars No. 94, 95, 107, 108, 111, 112, 114 *and* 120, *cut from plates of boiler iron, manufactured*

No. of bar under trial.	Direction of the slit in cutting the bar.	No. of exp.	DATE.	Length of the bar before trial.	Breadth.	Thickness.	Area before trial of the section of fracture.	Temp. Fah.	Breaking weight in the scale.	Br. wt. × leverage.	Friction.	Effective strain.
			1832.									
94	L'gth.	1	April 21,	24.07	1.074	.252	.270648	68.°	511	15330	766	14564
"	"	2	"		1.083	.252	.272916	70.75	550	16500	825	15675
"	"	3	"		1.060	.252	.267120	70.5	560	16800	840	15960
"	"	4	"		1.083	.252	.272916	73.75	574	17220	861	16359
"	"	5	"		1.062	.252	.267524	70.75	581	17430	871	16559
95	Cross.	6	April 25,	24.10	1.006	.238	.239428	62.25	382	11460	573	10887
"	"	7	June 10,		1.040	.241	.250640	79.5	431	12930	646	12284
"	"	8	"		1.060	.210	.222600	79.5	448	13440	672	12768
"	"	9	"		.792	.236	.186912	79.5	341	10230	511	9719
"	"	10	"		1.046	.237	.247902	79.5	493	14790	739	14051
107	Cross.	11			1.035	.072	.074520	70.75	145	4350	217	4133
"	"	12			.985	.078	.076830	70.75	151	4530	226	4304
"	"	13			1.083	.078	.084474	70.75	169	5070	253	4817
108	Uncer.	14		21.6	1.130	.076	.085880	62.	115.5	3465	173	3292
111	"	15		22.4	1.046	.146	.152716	62.	225	6750	337	6413
112	"	16		21.7	1.050	.136	.142800	62.	205.5	6165	308	5857
114	"	17			.914	.240	.219360	62.	469.4	14082	704	13378
120	"	18		22.8	.980	.272	.266560	62.	430.5	12915	645	12270

TABLE XLIII.

by R. Lukens, Chester Co. Pa. The sect's of frac. were those of the bars as they came from the shears.

Strength in pounds per square inch.	Weights producing elongation.	Elasticity of the bar.	Length after trial.	Area after trial.	REMARKS.
53811	224	37'			
	280	45			
	336	38			
	392	36			
	448	25			
	483	25			
	511	Broke.			
57435				1.068×.212 =.226416	Broke within the wedges. Area after fracture 83 per cent. of the area before trial.
59748				.989×.201 =.198789	Area after fracture, 70 per cent.
59941				.994×.190 =.188860	This fracture developed a remarkably clear and compact structure. Area 69 per cent.
61897				.990×.223 =.220770	Area after fracture, 82 per cent.
45471	224	34	24.19	.970×.214 =.207580	Area after fracture, 87 per cent.
	336	26			
	382	Broke.			
48994				.973×.200 =.194600	Area after fracture, 77 per cent.
55184				1.030×.208 =.214240	Broke at an original section. Area after fracture .96 per cent.
51998				.765×.213 =.162945	Area after fracture, 87 per cent.
56680				1.050×.209 =.219450	Area after fracture, 89 per cent.
55461				1.035×.070 =.072450	Broke at an original section; a filed section had been made = .985×.978=.077830, which tho' smaller in one direction was greater in the other, and of greater area than the section of fracture. Area after fracture, 97 per cent.
56020				.954×.066 =.062964	Area after fracture, 70 per cent.
57035				1.083×.061 =.066063	Area after fracture, 78 per cent.
38332			22.6	1.030×.062 =.063860	Area after fracture, 74 per cent.
41926			22.8	.994×.110 =.109340	Area after fracture, 71 per cent.
41015			22.5		
60986					
46031			23.5		The mean area of the sections of fracture *after trial* is 80.7 per cent. of the mean area of the same sections *before trial*.

TABLE XLIV.

Experiments on bars No. 125, 130, 133, 135 and 137. Manufactured by Messrs. S. E. H. & P. Ellicott, of Baltimore. The ore obtained on the Patapsco, 8 miles from Balt., reduced at Elkridge furnace, and forged at Patuxent forge, in the neighbourhood of that city. A slab was drawn out under the ham-

No. of the bar.	Direction of the slit.	No. of exp.	DATE.	Length before trial.	Breadth.	Thickness.	Area of section before trial.	Temperature Fah.	Br. weight in the scale.	Br. weight × leverage.	Friction.	Effective strain.
			1832.									
125	L'gth,	1	June 13.		1.060	.150	.159000	394.°	319	9570	478	9092
125	"	2	"		.982	.154	.151228	394.	336	10080	504	9576
125	"	3	"		.982	.154	.151228	82.	350	10500	525	9975
130	Cross.	4		16.6	1.052	.248	.260896	60.	529	15870	793	15077
133	Cross.	5	June 20.		1.003	.130	.130390	214.	259	7770	388	7382
133	"	6	"		.900	.137	.123300	214.	265	7950	397	7553
133	"	7	"		1.022	.140	.143080	394.	284	8520	426	8094
133	"	8	"		.817	.150	.122550	74.	300	9000	450	8550
133	"	9	"		.890	.165	.146850	74.	274	8220	411	7809
135	Diag.	10			.462	.247	.114114	78.	249	8470	423	8047
135	"	11		24.	1.020	.247	.251940	84.	422	12666	633	12027
135	"	12			1.012	.247	.249964	84.	442	13260	663	12597
135	"	13			1.012	.247	.249964	84.	451	13530	676	12854
135	"	14			1.012	.247	.249964	84.	451	13530	676	12854
137	Diag.	15	June 13.		1.040	.271	.281840	79.5	498	14940	747	14193
137	"	16	"		.950	.248	.235600	80.	469	14070	703	13367
137	"	17	"		.972	.262	.254664	212.	529	15870	793	15077
137	"	18	"		.850	.254	.215900	212.	515	15450	772	14678

TABLE XLIV.

mer and cut in three different ways, viz. 125 **longitudinally** *with the grain;* 130 *and* 133 *transversely, and* 135 *and* 137 **diagonally.** *The pieces thus cut off, subsequently drawn with the small hammer to nearly the size indicated in the column of areas. In some instances, reduced by filing at particular sections.*

Strength in lbs. per sq. inch.	Wt. producing temporary elongation.	Elasticity of the bar.	Length after trial.	Area of the section of fracture after trial.	REMARKS.
57182				.892×.091 =.081172	Broke out of the oil—near the wedges.
63322					Do. do. Calculating on the filed section, we find it bore the w'ght per in. here noted. As the actual section of fracture was not gauged before trial, we cannot determine precisely the str'gth at that point.
65960				.840×.089 =.074760	Broke at the filed section.
57789	56	08.′	16.6	.952×.210 =.199920	The elasticity under a weight of 336 lbs. in the scale, was taken after the weight had been suspended 15 hours.
	112	08.5			
	168	09.	16.6		
	224	11.	16.6		
	280	13.5			
	336	12.			
	436	16.			
	466	12.	16.725		
	485	16.			
	506	24.	16.975		
	529	Broke.	17.13		
56614				.893×.091 =.081203	Broke outside of the oil at a filed section not the *smallest.*
61168				.775×.090 =.069750	Broke in oil at filed section.
56570				.921×.100 =.092100	Broke out of the filed section at a thick part of the bar.
69767				.723×.100 =.072300	Broke at filed section.
53176				.728×.104 =.075712	Broke at a filed section.
70517				.368×.153 =.056304	The strength deduced, is that of the smallest filed section. The section actually fractured, was .310×.247=.125970 giving a strength of 63880 lbs.
47738				.790×.150 =.118400	Before this fracture the bar had been extended 1.9 inches.
50039				.787×.160 =.125920	The whole bar had now become irregular with alternate large and small sections.
51423				.825×.168 =.138600	No stretching except very near the section of fracture.
51423				.800×.178 =.142400	Point of fracture obs'd to be very warm.
50358	490	44.′		.802×.176 =.141152	Original section, as hammered.
	498	Broke.			
56736	336	20.		.772×.158 =.121996	Filed section.
	420	40.			
	469	Broke.			
59203					Heated in oil to 212°. Broke outside of the oil, near the wedges.
67939				.745×.170 =.126650	Broke in the oil at the filed section.
					The mean area of the 16 sections after fracture is 55.6 per cent. of the corresponding areas before trial.

TABLE XLV.

Experiments on bars No. 148, 151, 167 *and* 169. *Manufactured by S. E. H. & P. Ellicott. The ore obtained on the Patapsco,* 8 *miles from Baltimore. Rolled in the usual manner into boiler plate, and these strips*

No. of the bar.	Direction of the slit.	No. of the experiment.	DATE.	Length of the bar before trial.	Breadth.	Thickness.	Area of the section before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in pounds per square inch.
			1832.										
148	Cross.	1	May 2,		1.006	.250	.251500	64°	463	13890	694	13196	52468
148	"	2	"	20.6	.994	.250	.248500	64	476	14280	714	13566	54591
148	"	3	"		.755	.243	.183465	394	449	13470	673	13797	69752
148	"	4	"		.690	.253	.174570	81	399	11970	598	11372	65143
151	Cross.	5	"	30.5	1.008	.250	.252000	64	476	14280	714	13566	53811
151	"	6	"	29.8	1.016	.250	.254000	64	489	14670	733	13937	54868
151	"	7	"		.958	.248	.237584	64	503	15090	754	14336	60344
151	"	8	"		1.036	.250	.259000	64	503	15090	754	14336	54820
151	"	9	"		1.008	.248	.249984	64	504	15120	756	14364	57459
167	Cross.	10	May 9,	30.4	.942	.160	.150720	69	292	8760	438	8322	55222
167	"	11	"	27.2	1.004	.156	.156624	69	296	8880	444	8436	53862
167	"	12	"	19.33	.992	.156	.154752	69	307	9210	460	8750	56539
169	Cross.	13	"	30.1	1.032	.132	.136224	69	240	7200	360	6840	50212
169	"	14	"		1.032	.132	.136224	69	240	7200	360	6840	50212
169	"	15	"		1.032	.132	.136224	69	240	7200	360	6840	50212
169	"	16	"		1.000	.132	.132000	69	240	7200	360	6840	51818
169	"	17	"		1.000	.132	.132000	69	254	7620	381	7239	54841
169	"	18	"		1.020	.132	.134640	69	277	8310	415	7895	58839

TABLE XLV.

cut off with the shears across the direction of rolling. Reduced by filing from about one inch in breadth, in some of the experiments to the sections recorded; in others the bars left as they came from the shears.

Weights producing elongation.	Elasticity of the bar.	Length after trial.	Area of the section after fracture.	REMARKS.
212	29′			
336	33			
392	42		.248000	Fracture at an original section.
448	45			
463	Broke.			
463	37′	20.9	.205792	Broke at the smallest section, fracture compound.
476	Broke.			Broke suddenly at the filed section, but not by any sudden addition of weights.
				Broke at the filed section, a fair experiment.
224	30′			
336	33			A filed section was made near one end of the bar
448	40	30.9	.225096	but the fracture took place near the other end.
476	Broke.			
476	36′		.224200	Broke partly within the wedges.
489	Broke.			
				Broke at the *filed section*. The four other sections
			.185120	show 8.4 per cent. less strength on an average than this.
			.208320	Broke at an unfiled section.
			.220000	Do. do.
224	38′			
266	36	31.1	.097812	Section filed in the breadth, fracture much warmer
284	42			than the hand at the moment of breaking.
292	Broke.			
		27.33	.114228	Original section, fracture warm.
306	29′	19.4	.112840	Broke at the smallest section.
307	Broke.			
				Broke at two places at a distance from each other.
			.096200	All the fractures on this bar were made at *original*
				or unfiled sections.
			.116560	
			.121088	Two fractures occurred simultaneously near each other.
			.095800	
253	44′		.112632	
254	Broke.		.125748	
				The whole bar has now been extended from 30.1 to 31.3 inches by these six fractures. The number of points actually separated was 8, two fractures having twice occured at the same moment.

TABLE XLVI.

Experiments on bars No 154, 157, 171 *and* 174, *and Nos.* 142 *and* 143. *Manufactured by Messrs. S. E. H. & P. Ellicott. The ore obtained on the Patapsco, 8 miles from Baltimore, rolled into boiler-plate in the usual manner. The first four strips cut off diagonally, and the last two longitudinally with the*

No. of the bar.	Direction of the slit.	No. of exp.	DATE.	Length before trial.	Breadth.	Thickness.	Area before trial.	Temperature, Fah.	Br. weight in the scale.	Br. weight X leverage.	Friction.	Effective strain.	Strength in lbs. per sq. inch.
			1832.										
154	Diag.	1	May 5.	30.4	.952	.250	.238000	60.°	427	12810	640	12170	51134
154	"	2	"	23.08	.960	.250	.240000	60.	438	13140	657	12483	52012
154	"	3	"		.900	.250	.225000	60.	464	13920	696	13224	58773
157	Diag.	4	"	30.35	1.024	.250	.256000	62.	468	14040	702	13338	52102
157	"	5	"		1.000	.250	.250000	66.5	469	14070	703	13367	53468
171	Diag.	6	May 12	30.2	.960	.134	.128640	69.	251	7530	37 6	7154	55612
174	Diag.	7	"	30.2	.896	.132	.118272	69.	235	7050	352	6698	56632
174	"	8	"	27.7	.972	.134	.130248	69.	235	7050	352	6698	51425
174	"	9	May 19	23.9	.974	.134	.130516	69.	246	7380	369	7011	53717
174	"	10	"	22.1	.956	.136	.130016	69.	246	7380	369	7011	53924
142	L'gth.	11	Ap. 18.	30.4	1.110	.240	.266400	62.	415	12450	622	11828	44399
143	L'gth.	12	Ap. 25.	30.6	1.000	.236	.236000	62.	440	13200	660	12540	53135
143	"	13	"	29.3	1.034	.236	.244024	62.	478	14340	717	13623	55826
143	"	14	"		.944	.238	.224672	62.	478	14340	717	13623	60635
143	"	15	May 2.		1.014	.236	.239304	64.	495	14850	742	14108	58954

TABLE XLVI.

sheets. Tried either at original sections, or at points more or less reduced by filing from the breadth a semicircular cavity on each edge. The bars originally cut one inch wide.

Wt. producing tem. elongation.	Elasticity of the bar.	Length after frac.	Area after trial.	REMARKS.
224	30.′	30.52	.215740	Did not break at the smallest section.
336	30.			
392	38.			
420	42.			
427	Broke.			
392	21.		.212676	Do.
438	Broke.			
434	22.		.189200	Broke *near* the smallest section.
449	25.			
459	26.5			
464	Broke.			
224	27.	31.0		A section was filed in the breadth of the bar so as to leave an area of .962 X .25=.240500 of a sq. inch; while the smallest original section was 1.018 X .248=.251968, and the section actually broken was .256000. Calculating on the filed section we obtain a strength of more than 55459, because the bar was *not broken* at that point.
336	50.			
392	50.			
420	51.			
438	49.			
448	48.			
462	46.5			
468	Broke.		.994 × .212 = .210728	This on the same filed section shows a strength a little above that calculated in the preceding remark.
224	18.	30.5	.962 × .122 = .117364	Broke in the middle of the bar.
251	Broke.			
219	44.5	30.7	.796 × .102 = .081192	Filed.—Broke at the filed section.
227	50.5			
235	Broke.			
231	1.05	27.9	.950 × .120 = .114000	Do. do.
235	Broke.			
231	41.	24.1	.950 × .114 = .108300	Do. do.
245	44.			
246	Broke.			
245	39.	22.3	.934 × .116 = .108344	Do. do.
246	Broke.			
112	08.5	31.1	1.09 × .230 = .250700	Original section.
224	14.			
280	15.			
336	27.			
364	26.5			
380	32.			
398	31.5			
415	Broke.			
224	30.	31.3		Did not break at the smallest section. After the elasticity had been taken under 440 lbs. the same weight broke the bar.
280	33.			
336	48.			
370	53.			
392	52.			
435	44.			
440	47.			
440	Broke.			
464	41		.994 × .186 = .184884	Did not break at the filed section, though its area was only .944 X .238=.224672.
478	Broke.		.800 × .152 = .121600	Br. at the filed section noted in the preceding remark.
485	37.5		.990 × .214 = .211860	The elasticity may be very slightly erroneous, as the index rose a little way above the top of the scale. When the bar appeared to be giving way under 494 lbs., 9 lbs. were taken off, so as to leave 485, with which the elasticity was again tried, and found to be 33.6′. Having restored the 9 lbs. the elasticity was again tried, and found 34.5′ for the whole weight.
485	33.5			
495	36.5			
495	Broke.			

TABLE XLVII.

Experiments on bars No. 160, 162, and 164. Manufactured by S. E. H. & P. Ellicott. The ore was obtained on the Patapsco, 8 miles from Baltimore, rolled into boiler plate in the usual manner,

No. of the bar.	Direction of the slit.	No. of the experiment.	DATE.	Length of the specimen before trial.	Breadth of the section before trial.	Thickness before trial.	Area of the section before trial.	Temperature Fahrenheit.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in lbs. per square inch.
			1832.										
160	L'gth.	1	May 2.	30.2	.862	.136	.117232	60°	245	7350	367	6983	59565
160	"	2	"	27.2	.946	.126	.119196	60	250	7500	375	7125	59775
160	"	3	"	22.25	1.000	.130	.130000	60	257	7710	385	7325	56346
160	"	4	"		.612	.124	.075888	48	175	5250	262	4988	65725
160	"	5	May 7.		1.016	.130	.132080	60	272	8160	408	7752	58691
160	"	6	"		1.040	.134	.139360	60	290	8700	435	8265	59307
162	L'gth.	7	May 9.	30.2	.858	.136	.116688	69	256	7680	384	7296	62526
162	"	8	"	27.6	.998	.132	.131736	69	262	7860	393	7467	56682
162	"	9	1833.	19.4	1.000	.136	.136000	69	280	8400	420	7980	58677
162	"	10	Jan. 24.		.647	.134	.086698	48	225	6750	337	6413	73969
162	"	11	"		.750	.114	.085500	49	234	7020	351	6669	78000
162	"	12	Jan. 26.		.656	.130	.085280	56.5	224	6720	336	6384	74859
164	L'gth.	13			.747	.132	.098604	576	233	6990	349	6641	66336
164	"	14			.711	.135	.095985	87.5	203	6090	304	5786	60280
164	"	15			.731	.138	.100878	87.5	200	6000	300	5700	56503
164	"	16			.734	.140	.102760	87.5	196	5880	294	5586	54361
164	"	71			.780	.139	.108420	578	253	7590	379	7211	66510
164	"	18			.683	.135	.092205	74.	198	5940	297	5643	61200
164	"	19			.714	.135	.096390	74.	208	6240	312	5928	61500

TABLE XLVII.

(method of refining not stated.) These strips cut off lengthwise *of the sheet. Reduced in some instances by filing, and in others tried in the state in which they came from the shears. Specific gravity* 7.7.

Weight producing extension.	Elasticity of the bar indicated by the recoil.	Length of the bar after trial.	Area of the section of fracture after trial.	REMARKS.
224 245	1°.22′ Broke.	30.85	.079764	Broke at a filed section.
			.090240	Do.
252 257	1.04′ Broke.	27.3	.096304	Do.
				Deeply filed section, bore 175 pounds, for a while sunk from 0 with it, but broke on taking up the screw.
262 272	0.42′ Broke.		.101388	Unfiled section.
280 290	0.35′ Broke.		.128000	Do.
168 224 252 256	1°.00′ 1.05 0.58* Broke.	30.8	.079600	Broke at the filed section. * This elasticity taken within 4 lbs. of the breaking weight.
262 262	1°.12′ Broke.	28.0	.103800	A section was filed on the sides to remove completely the scale of oxide from the bar at that part. But the fracture did not take place at the filed section though its area was only .116820; while that of the section of fracture was .131736. Calculated on the section filed, the strength was *above* 63917 lbs per square inch.
		19.7		Original section.
				This experiment was on a deeply filed section.
				Do.
				Bore this weight for some time and then broke without addition.
			.068701	Fracture at the filed section forming a bevel like the cutting part of a mortising chisel.
			.047333	Fracture of the usual appearance of *cold* bars.
			.042560	Do.
			.041400	Broke immediately on applying this weight.
			.067800	This fracture smooth and sharp like the first experiment and of the same form.
			.043500	Fracture as usual in cold experiments.
			.048030	Do. Do.

TABLE XLVIII.

Experiments on bar No. 146. *Manufactured by Messrs. S. E. H. & P. Ellicott. Rolled into boiler plate in the usual manner, and this strip cut off lengthwise of the sheet. Reduced by filing, after having been cut with the shears. The dimensions of the specimen before trial*

Dimensions taken after certain exp's. had been made or given whts. borne by the bar.

Measures after a strain of 328 pounds. Oct. 17, 1832.				After the second fracture.				After the 6th experiment.				No. of the experiment.	DATE.	Temp. Fah.
Marks.	Breadth.	Thickness.	Area.	Marks.	Breadth.	Thickness.	Area.	Marks.	Breadth.	Thickness.	Area.			
1	.888	.200	.177600	1	.874	.198	.173052	16	.861	.201	.173061			
5	.888	.200	.177600	2	.865	.196	.169540	17	.856	.201	.172056		1832.	
8	.891	.200	.178200	3	.867	.192	.166464	18	.873	.202	.176346	1	Oct. 20.	56°
12	.882	.204	.179928	4	.869	.192	.166848	19	.868	.200	.173600			
13	.882	.203	.179046	5	.868	.199	.182732	20	.856	.200	.171200			
17	.880	.209	.183920	6	.857	.199	.170543	20½	.854	.200	.170800	2	"	58
20½	.886	.209	.185174	7	.857	.195	.167115	21	.858	.199	.170742			
24½	.882	.207	.182574	8	.866	.197	.170602	22	.869	.200	.173800			
				9	.873	.202	.176346	23	.866	.200	.173200	3	Oct. 27,	54
Meas. taken after first frac.				10	.866	.200	.173200	24	.848	.197	.167056			
1	.875	.198	.173250	11	.865	.198	.171270	24½	.838	.199	.166762			
2	.881	.196	.172676					25	.863	.201	.173463			
3	.883	.200	.176600	After the fourth fracture.										
4	.883	.197	.173951	1	.870	.197	.171390	After the tenth fracture.						
5	.879	.200	.175800	2	.856	.193	.165208	16	.844	.202	.170488	4	"	55
6	.874	.200	.174800	3	.848	.190	.161120	17	.852	.201	.171252			
7	.873	.200	.174600	3½	.847	.187	.158389	18	.866	.202	.174932			
8	.880	.200	.176000	4	.855	.192	.164160	19	.851	.200	.170200			
9	.879	.201	.176679	5	.860	.195	.167700	20	.854	.199	.169946	5	Nov. 3,	58
10	.879	.202	.177558	6	.843	.198	.166914	21	.855	.197	.168435			
11	.867	.201	.174267					22	.863	.200	.172600			
12	.867	.200	.173400	After the seventh fracture				23	.861	.201	.173061			
13	.805	.191	.153755	1	.862	.196	.168952	24	.794	.180	.142920	6	"	56
13½	.788	.165	.130020	2	.854	.192	.163968							
14	.845	.198	.167310	3	.848	.189	.160272	During the 14th experiment smallest section.						
15	.862	.201	.173262	3½	.846	.187	.158202		.835	.193	.161155			
16	.868	.204	.177072	4	.855	.192	.164160	18	.864	.200	.172800	7	Nov. 10,	52
17	.865	.205	.177325	5	.859	.196	.168364					8	"	52
18	.880	.203	.178640											
19	.872	.201	.175272									9	"	52
20	.875	.203	.177625											
21	.874	.201	.175674									10	"	54
22	.884	.202	.178568											
23	.883	.207	.182781									11	"	50
24	.866	.207	.179262											
25	.873	.205	.178965									12	Nov. 15,	90
												13	"	80
												14	"	70

TABLE XLVIII.

were, length 25½ inches, breadth .893, and thickness .207, giving the area of cross sections=.184851 of a square inch. Marked and numbered before trial at every inch of the length. Spec. grav. 7.739. Original dimensions before filing, 1.01×.24=.242400, area of section.

Breaking weight in the scale.	Br. weight × leverage.	Friction.	Effective strain.	Strength in lbs. per square inch.	Point fractured.	REMARKS.
393	11790	589	11201	60594	No. 13⅔	Part in hot oil from 1 to 5; in ice from 20½ to 24½. Strained with 328 lbs. then gauged as stated. Increase of length by that wht. .3 inch in 25.5. When the oil was 566,° the part at No. 9 was at 212°.
424	12720	636	12084	65371	" 12	When put in, this piece measured 13.85 inches in length. After frac. it was 14.6.
437	13110	655	12455	67378	Broke between the wedges.	This fracture took place at the coldest part, say at about 100°. After frac. one portion, viz. from 9 to 10, was found to measure in Breadth. .760, Thick. .163, Area .123880.
446	13380	669	12611	68222	" 6½	Before this fracture was made, the bar had been put under a strain of 429 lbs. and a temperature of 545°. Then suffered to cool down to 56°. By again heating it up to 446 the index fell 33′, and by raising the temperature to 540° it fell in all 48′.
405	12150	607	11543	62445	" 15.1	Fracture near the wedges. This and the following experiment were made on a different part of the bar from the preceding.
431	12930	646	12284	66453	Not parted.	Part in oil from 14 to 18. At the temp. and wht. here recorded the oil accidentally took fire, which caused the experiment to be suspended. The bar was subsequently heated again in experiment 10th.
462	13860	693	13167	71253	At a part ungauged near No. 1.	After this experiment this part of the bar was again gauged.
463	13890	694	13196	71387	" 5½	Fracture just within the wedges.
469	14070	703	13367	72312	" 5	Frac. very bright and crystalline–directly across–with little diminution of area–a flaw now appears in this part of the bar.
467	14010	700	13310	72004	" 24	Part now in, is from 16 to 24½, same part in oil as in the 6th experiment.
464	13920	696	13224	71539	Within the wedges.	The point of frac. was judged to be heated to above 130° as it could not conveniently be held in the hand.
476	14280	714	13566	73389	Not noted.	The temperature marked in this experiment is only *approximate.*
477	14310	715	13595	73546	Do.	
485	14550	727	13823	74779	Near 18.	After the weight 485 had been applied the bar was taken out and gauged, then returned and broke, but not at the smallest sect.

TABLE XLIX.

Experiments on bar No. 149. Manufactured into boiler plate by Messrs. S. E. H. & P. Ellicott. The ore obtained on the Patapsco, 8 miles from Baltimore; rolled in the usual manner, and this strip cut

Marks.	Breadth	Thickness.	Area before trial at the points measured.	No. of the experiment.	DATE.	Area of the section of fracture before trial.	Temperature Fahrenheit.	Breaking weight in the scale.	Breaking weight multiplied by leverage.	Friction.	Effective strain.
0	.762	.248	.188976		1833.						
1	.762	.247	.188214	1	Oct. 10,	.180357	66	334	10020	501	9519
2	.760	.242	.183920								
3	.760	.242	.183920								
4	.760	.243	.184680	2	"	.182259	750 approx.	334	10020	501	9519
5	.761	.248	.188728								
6	.760	.248	.188480	3	Oct. 12,	.184680	61	369	11070	553	10517
7	.760	.245	.186200	4	"	.186770	61	371	11130	556	10574
8	.760	.243	.184680	5	"	.183920	62	375	11250	562	10688
9	.761	.237	.180357	6	"	.188666	62	380	11400	570	10830
10	.762	.242	.184404								
11	.762	.246	.187452								
12	.762	.240	.182880	7	"	.185669	825	369	11070	553	10517
13	.762	.237	.180594								
14	.762	.239	.182118								
15	.760	.240	.182400	8	"	.182309	63.5	380	11400	570	10830
16	.760	.240	.182400								
17	.761	.240	.182640								
18	.761	.239	.181879								
19	.762	.240	.182880	9	"	.183381	770	356	10680	534	10146
20	.763	.240	.183883								
21	.763	.244	.186172								
22	.764	.241	.184124								
23	.763	.243	.185409	10	Oct. 17,	.182400	69	397	11910	595	11315
24	.763	.245	.186935	11	"	.182630	69	397	11910	595	11315
25	.762	.242	.184404	12	"	.184455	69	403	12090	604	11486
26	.762	.240	.182880	13	"	.185088	69	410	12300	615	11685
27	.762	.238	.181356	14	"	.182118	69	401	12030	601	11429
28	.762	.239	.182118								
29	.769	.235	.180715		Mn. of 14 =	.183907					
Mean of 30			.184193								
Maximum			.188976								
Minimum			.180357								
Mn. of the 2			.184666								
Diff. of the 2			.008619								

TABLE XLIX.

off by the shears across the direction of the rolling. Reduced by filing from about one inch in breadth and ¼ inch in thickness to the dimensions recorded. Specific gravity, 7.7774.

Strength in lbs. per sq. inch.	Point of fracture.	REMARKS.
52778	No. 9	More than 24 inches under trial. After several trials to ascertain the weight producing the first permanent extension, it was found to be attained with 224 pounds in the scale.
52228	" 14½	Part in tin from 13 to 16½. Too much water in the pyrometer---dashed over a little. The No. 780+212, originally marked, is certainly too high.
56947	" 8	The part now under trial was that broken off in the first exp.
56615	" 6¾	
58112	" 2½	
57403	" 5¼	
56644	" 24½	The part now in is from 22 to 25½. The bar stretched for some time, and as the furnace was not lowered, the standard piece had probably at the moment before taking the temperature, attained a greater degree of heat than was absolutely necessary to break the bar under this weight.
59494	" 12¼	
54781	" 19½	Part in metal from 18 to 21. The temperature was raised gradually until the bar appeared about to give way; then lowered the furnace and diminished the heat till the lever ceased to descend. Repeated this three times and at last when a decided evidence of fracture was given the temperature was taken with care, and is therefore regarded as very correct.
62034	" 15½	
61955	" 18¾	
62269	" 20¼	Broke in the gripe of the wedges.
63132	" 22¾	
62755	" 28	

The mean area of the sections of fracture is .000286 square inch *less* than the mean area of the measured sections.

TABLE L.

Experiments on bar No. 150. *Manufactured by Messrs. S. E. H. & P. Ellicott. The ore obtained on the Patapsco,* 8 *miles from Baltimore. Rolled in the usual manner, and this strip cut off by*

Marks.	Breadth.	Thickness.	Area of section at the points gauged before trial.	DATE	No. of the exp't.	Area of the section of fracture before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in lbs. per square inch.	Weight producing elongation.
0	.719	.236	.169684										196
1	.720	.236	.169920										294
2	.721	.236	.170156										301
3	.718	.237	.170166	1833.									308
4	.720	.234	.168480	Sept. 26,	1	.166020	81°	346	10380	519	9861	59397	315
5	.717	.236	.169212										322
6	.722	.236	.170392										329
7	.722	.236	.170392										336
8	.722	.235	.169670										343
9	.721	.234	.168714										346
10	.718	.234	.168012										
11	.717	.232	.166344	"	2	.169485	662	346	10380	519	9861	58182	
12	.721	.232	.167272										
13	.719	.232	.166808	"	3	.168470	75	345	10350	517	9833	58366	
14	.717	.231	.165627										
15	.724	.232	.167968	"	4	.166808	75	380	11400	570	10830	64925	
16	.724	.232	.167968	"	5	.170301	734	346	10380	519	9861	57903	
17	.723	.231	.167013										
18	.721	.230	.165830	Sept. 28,	6	.168714	68	368	11040	552	10488	62164	
19	.721	.232	.167272	"	7	.167272	68	382	11460	573	10887	65086	
20	.722	.234	.168948	"	8	.170392	68	340	10200	510	9690	56869	
21	.723	.235	.169905	"	9	.169605	68	361	10830	541	10289	60664	
22	.722	.233	.168226	"	10	.169684	68	368	11040	552	10488	61809	
23	.721	.234	.168714	"	11	.169920	68	377	11310	565	10745	63235	
24	.723	.237	.171351										
25	.725	.237	.171825										
26	.722	.233	.168226	"	12	.170166	68	388	11640	582	11058	64983	
27	.720	.234	.168480										
28	.719	.232	.166808										
				Oct. 3,	13	.167226	63	386	11580	579	11001	65785	
Mean of 29 =			.168599	"	14	.170692	63	388	11640	582	11058	64783	
				"	15	.168311	63	388	11640	582	11058	65700	
Maximum =			.171825										
Minimum =			.166344										
				"	16	.167963	63	359	10770	538	10232	60917	
Mn of these 2			.169084										
Diff. of the 2			.004491	"	17	.167272	63	372	11160	558	10602	63382	
				"	18	.166615	63	382	11460	573	10887	65342	
				Mn. of 18 =		.168606							

TABLE I.

the shears, across the direction of the rolling. Reduced by filing from about one inch in breadth and one-fourth inch in thickness, to the dimensions recorded. Specific gravity, 7.7774.

Observed elongations of the bar under the several weights.	Point fractured.	REMARKS.
1st perm. elong.		
.30 in 24 in.		
.40 "		
.50 "		
.60 "		
.73 "	No. 13¾	
.90 "		
1.14 "		
1.42 "		
Br. as per rec.		
	" 21½	The temperature is perhaps not quite accurate on account of the standard piece having fallen. Part in tin from 19 to 23. *Broke in the tin.*
	" 22½	Broke at a part which had been heated.
	" 28½	
	" 7⅞	Part in tin from 4½ to 8¼.
	" 9	
	" 12	
	" 6¼	Broke very soon after the weight was applied.
	" 5½	
	" 0	Not heated.
	" 1	
	" 3	When the weight had been added to the amount of 383 lbs. the machine was relieved and oiled to ascertain whether the friction had before been above our estimate; but no effect was perceptible.
	" 27¾	
	" 23¾	
	" 26½	
	" 15	Part now under trial from 13¾ to 21. Fracture shows three distinct laminæ, of which the central one appears more coarse grained than the two outside ones.
	" 19	
	" 17⅓	
		The mean area of 18 fractures, is .000007 square inch *greater* than the mean area of the 29 measured sections.

TABLE LI.

Experiments on bar No. 152. *Manufactured by Messrs. S. E. H. & P. Ellicott. The ore obtained on the Patapsco, eight miles from Baltimore. Rolled into boiler plate and this strip cut* across *the sheet.*

Marks.	Breadth.	Thickness.	Area of section at the points measured.	No. of the experiment.	DATE.	Area of the section of fracture.	Temp. Fah.	Breaking wht. in the scale.	Breaking wright × leverage.	Friction.	Effective strain.	Strength in lbs. per sq. inch.
0	.733	.232	.170056		1833.							
1	.733	.233	.170789	1	Sept. 14.	.171230	66°	348	10440	522	9918	57922
2	.733	.235	.172255									
3	.733	.235	.172255	2	"	.173327	66	341	10230	511	9719	56073
4	.733	.235	.172255									
5	.731	.236	.172516	3	"	.173195	66	348	10440	522	9918	57405
6	.735	.236	.173460									
7	.729	.236	.172044	4	"	.172752	722	330	9900	495	9405	54442
8	.735	.236	.173460									
9	.735	.236	.173460									
10	.735	.234	.171990	5	Sept. 19.	.169050	1037	224	6720	336	6384	37764
11	.735	.231	.169785									
12	.735	.233	.171255									
13	.735	.235	.172725									
14	.735	.233	.171255	6	Sept. 21.	.172490	80	336	10080	504	9576	55516
15	.735	.230	.169050									
16	.735	.233	.171255	7	"	.170770	80	350	10500	525	9975	58412
17	.735	.230	.169050									
18	.734	.235	.172490	8	"	.171990	80	336	10080	504	9576	55678
19	.737	.236	.173932									
20	.737	.235	.173195	9	"	.172358	80	340	10200	510	9690	56220
21	.737	.235	.173195									
22	.737	.235	.173195	10	"	.171990	80	373	11190	559	10631	61809
23	.735	.236	.173460									
24	.735	.233	.171255	11	"	.170056	80	352	10560	528	10032	58992
25	.736	.233	.171488									
26	.737	.233	.171721	12	"	.173106	80.5	375	11250	562	10688	61742
27	.737	.232	.170984									
28	.738	.230	.169740	13	"	.172342	80.5	379	11370	568	10802	62677
Mean of 29			.171847	14	"	.172255	80.5	379	11370	568	10802	62709
Maximum			.173932		Mn. of 14 =	.171922						
Minimum			.169050									
Mn. of these 2			.171491									
Diff. of the 2			.004882									

TABLE LI.

Reduced by filing from one inch in breadth to the dimensions recorded, and gauged at every inch, from 0 *to* 28 *inclusive. Specific gravity,* 7.7774.

Point fractured.	REMARKS.
No.	
$26\frac{3}{4}$	
$22\frac{1}{2}$	Broke very soon after applying the wht. recorded.
$20\frac{3}{4}$	Broke by a gradual application of weights.
$7\frac{1}{2}$	Fracture oblique to the bar.
15	At this trial the condenser of the steam pyrometer was employed. When the equilibrium had been reproduced by the revolving weight it continued without the slightest alteration for half an hour.
18	Broke at the part heated—a flaw discovered in the interior of the bar.
$17\frac{1}{2}$	
$13\frac{1}{2}$	Broke on first applying the weight—result supposed rather too high.
$12\frac{3}{4}$	
10	
0	
$6\frac{1}{4}$	
$4\frac{1}{2}$	
$3\frac{3}{4}$	

Measured after this exp. .640 87 per cent. of ori. br'th. | .198 81.7 pr. ct. of ori. thick. | .126720 74.3 per ct. of the original area.

The mean area of the sections of fracture is .000075 *greater* than the mean area of the 29 measured sections.

TABLE LII.

Experiments on bars No. 200 *and* 201, *cross strips, and on* 206, 207 *Gerard Ralston, Esq.*

No. of the bar.	Direction of the slit.	DATE.	No. of the exp't.	Breadth before trial.	Thickness before trial.	Areas of section before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.
		1833.								
200	Cross.	Aug. 4,	1	.760	.160	.121600	81.°	226	6780	339
200	"	"	2	.658	.160	.105280	81.	190	5700	285
200	"	"	3	.778	.166	.129148	81.	182	5460	273
201	Cross.	"	4	.645	.159	.102555	81.	169	5070	253
206	Length.	"	5	.697	.165	.115005	81.	216	6480	324
206	"	"	6	.500	.165	.082500	81.	163	4890	244
206	"	"	7	.807	.164	.132348	81.	205	6150	307
206	"	"	8	.657	.164	.107748	81.	192	5760	288
206	"	"	9	.753	.165	.124245	81.	213	6390	319
206	"	"	10	.663	.167	.110721	80.	196	5880	294
206	"	"	11	.594	.166	.098604	80.	203	6090	304
207	Length.	Aug. 1,	12	.654	.166	.108564	572.5	251	7530	376
207	"	"	13	.674	.167	.112558	580.	248	7440	372
207	"	"	14	.664	.167	.110888	78.	212	6360	318
207	"	"	15	.720	.167	.120240	84.	203	6090	304
207	"	"	16	.666	.167	.111222	573.5	245	7350	367
207	"	"	17	.658	.167	.109886	84.	190	5700	285
207	"	"	18	.730	.166	.121180	84.	230	6900	345
207	"	"	19	.680	.168	.114240	84.	215	6450	322
208	Length.	"	20	.662	.167	.110554	1000. appr.	112	3360	168
208	"	"	21	.725	.162	.117450	84.	215	6450	322

TABLE LII.

and 208, *length strips, from a sheet of English boiler-iron, furnished by*

Effective strain.	Strength in lbs. per square inch.	REMARKS.
6441	52968	Original breadth of the bar about one inch.—Broke at a filed section.
5415	51434	Do.
5187	40163	Do.
4817	46970	This result is probably rather too high, as the weight 169 lbs. broke the bar in a very short time.
6156	53528	Broke at a filed section.
4646	56315	About one-half of the original section was filed away to be sure of escaping the weakening effect of the shears.
5843	44149	The section now filed was obviously not deep enough. In a trial not recorded, a fracture was made entirely out of this filed part.
5472	50786	
6071	48863	The low result is here, probably, to be in part attributed to the deficiency of filing.
5586	50451	
5786	58679	This experiment and No. 2. were certainly made on sections sufficiently filed to test the full strength of the metal.
7154	65897	All the experiments on this bar, (No. 207,) were made at sections more or less filed. It was originally about one inch wide, and .167 inch in thickness. The filing was, in general, confined entirely to the edges, and not extended to the flat surfaces which had been exposed to the rolls.
7068	62794	
6042	54487	
5786	48120	
6983	62786	
5415	49278	
6555	54093	
6128	53641	
3192	28876	Heated by the flame of a spirit lamp applied directly under the bar. Pieces of rolled zinc were melted on the upper surface of the bar before it parted.
6128	52175	

TABLE LIII.

Experiments on bar No. 226. Boiler-plate iron. Manufactured by Messrs. Evan T. Ellicott & Co., of Baltimore. Origin of the metal and mode of manufacture not specified; supposed to be lamellated. *This*

Marks.	Breadth.	Thickness.	Area of measured sections before trial.	No. of the exp't.	DATE.	Area of the section of fracture.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in lbs. per square inch.
0	.763	.244	.186172									
1	.762	.244	.185928		1834.							
2	.761	.240	.182640	1	June 21.	.183026	80.°	315	9450	472	8978	49053
3	.762	.234	.178308									
4	.762	.241	.183642									
5	.760	.241	.183160									
6	.760	.241	.183160	2	"	.181799	80.	351	10530	526	10004	55028
7	.760	.239	.181640									
8	.760	.238	.180880									
9	.760	.240	.182400									
10	.759	.242	.183678	3	"	.177992	1237.	133	3990	199	3791	21298
11	.759	.241	.182919									
12	.762	.242	.184404									
13	.762	.240	.182880	4	June 28.	.185600	73.75	351	10530	526	10004	54488
14	.761	.239	.181879									
15	.760	.238	.180880									
16	.760	.240	.182400									
17	.760	.242	.183920	5	"	.180880	1317.	120	3600	180	3420	18913
18	.756	.239	.180684									
19	.757	238	.180066									
20	.753	.235	.176955									
21	.757	.233	.176381									
22	.767	.240	.184080									
23	.765	.240	.183600	6	"	.180880	1192.	120	3600	180	3420	18913
24	.765	.240	.183600									
25	.761	.239	.181879									
26	.760	.239	.181640	7	July 2.	.180684	83.	280	8400	420	7980	44165
27	.761	.239	.181879									
28	.766	.237	.181542	8	"	.183109	1245.	133	3990	199	3791	20703
Mean of 29			.182144									
Maximum			.186172	9	"	.183160	1142.	120	3600	180	3420	18672
Minimum			.176381									
Mn. of the 2			.181276	10	July 30.	.181629	80.	275	8250	412	7838	43154
				11	"	.182630	80.	306	9180	459	8721	47752
Diff. of the 2			.009791	12	"	.183425	80.	250	7500	375	7125	38843
				13	"	.181640	80.	285	8550	427	8123	44720
				14	"	.183160	80.	301	9030	451	8579	46839
				15	"	.183522	80.	343	10290	514	9776	53269
				16	"	.180086	80.	370	11100	555	10545	58551
				17	"	.185928	80.	382	11460	573	10887	58555
				Mean of 17		.182185						

TABLE LIII.

strip was cut off in the direction crosswise of the sheet, reduced by filing from 1 *inch in breadth and* $\frac{1}{4}$ *inch thick, to the dimensions given below. Specific gravity,* 7.7428.

Weights producing elongation.	Extension produced.	Point fractured.	REMARKS.
238	No perm. elonga.		
245	Elonga. decided.		
280	24.85 (wt. off, 24.82)	No. $24\frac{1}{3}$	Began the experiments on this bar by adding weights gradually from 210 lbs., and observing on a length of 24 inches, both when under strain and when relieved, the actual length of that portion. Cold fracture.
314	25.5, gain 1 1-2 in.		
315	Broke.		
		" $25\frac{1}{3}$	Fracture in the short piece broken off in the first experiment.
		" $19\frac{3}{4}$	Part heated from 17 to 21. The temp. was twice raised to the point of yielding. After the first trial it was allowed to abate; then raised again and broke the bar. If any variation from the true *breaking heat* existed, it was conjectured to be a trifle too high. But exp't 8 proves it to have been right, (see below.) The iron was distinctly red in day-light.
		" 24	
		" 15	In hot metal from thirteen to sixteen and a half. The temp. having been raised to the point where the bar had begun to yield rapidly, the fire was removed after taking that temp. by the pyrometer. The lever at length ceased to descend, and soon came to rest as the metal cooled. Distinctly red in day-light. As the bar was sometime strained with this weight, it had probably been so weakened as not again to require the same temperature.
		" 15	Part in metal from thirteen to sixteen and a half. The temp. had not risen so high as in the preceding trial when the bar began again to extend, and finally gave way. The heat was carefully managed by means of the suspended furnace and lever to avoid any excess. Not so red as before,—barely distinguishable in dusk.
		" 18	
		" $10\frac{3}{4}$	In tin from 8 to 12. This exp't, like the sixth, was made carefully by lowering the fire, when the bar appeared to be stretching too rapidly. Red in day-light.
		" 6	This fracture was doubtless made on a part of the bar which had been originally defective. The section of fracture was much less reduced than in the preceding trial, and was flaky in appearance. *Not visibly red in day-light.*
		" $14\frac{1}{3}$	
		" $13\frac{1}{4}$	
		" $10\frac{1}{3}$	
		" 7	
		" $5\frac{1}{8}$	
		" $4\frac{1}{4}$	
		" $3\frac{1}{3}$	
		" 1	
			The mean area of the 17 sections of fracture is *greater* by .000041 sq. inch, than the mean area of the 29 measured sections.

TABLE LIV.

Experiments on bar No. 227. Manufactured into boiler plate by Messrs. E. T. Ellicott & Co., of Baltimore. The mode of manufacture,

Marks.	Breadth.	Thickness.	Area at the points measured before trial.	No. of the experiment.	DATE.	Area of the section of fracture before trial.	Temp. Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.
0	.765	.235	.179775		1834.		°				
1	.765	.236	.180540	1	May 31,	.181005	70	342	10260	513	9747
2	.767	.237	.181779	2	"	.181512	70	349	10470	523	9747
3	.764	.237	.181068								
4	.766	.233	.178478								
5	.766	.232	.177712								
6	.766	.236	.180776	3	June 7,	.180421	1097	174.75	5242.5	262.12	4980.38
7	.767	.235	.180245								
8	.768	.235	.180480								
9	.766	.235	.180010								
10	.764	.235	.179540								
11	.767	.236	.181012								
12	.767	.233	.178711	4	"	.180437	1111	174.75	5242.5	262.12	4980.38
13	.767	.236	.181012								
14	.767	.236	.181012								
15	.769	.236	.181484								
16	.769	.238	.183022	5	June 14,	.182035	1187	140	4200	210	3990
17	.767	.238	.182546								
18	.767	.237	.181779								
19	.767	.239	.183313	6	"	.181632	1155	140	4200	210	3990
20	.768	.236	.181248								
21	.768	.235	.180480								
22	.768	.236	.181248	7	"	.180500	100	348	10440	522	9918
23	.768	.237	.182016								
24	.767	.237	.181779	8	"	.178733	90	397	11910	595	11315
25	.767	.237	.181779	9	June 21,	.180363	75	350	10500	525	9975
26	.767	.237	.181779	10	June 28,	.181897	73.75	291	8730	436	8294
27	.762	.239	.182118	11	"	.181779	73.75	341	10230	511	9719
28	.768	.237	.182016	12	"	.181779	73.75	344	10320	516	9804
				13	"	.181868	73.75	333	9990	499	9491
Mean of 29=			.180997	14	July 2,	.182290	84	288	8640	432	8208
				15	"	.182280	84	300	9000	450	8550
Maximum=			.183313								
Minimum=			.177712		Mn. of 15 =	.181182					
Mn. of the 2			.180512								
Diff. of the 2			.005601								

TABLE LIV.

source of the ore, kind of pig-metal, &c. not specified. Specific gravity, 7.6675. *This bar cut off* crosswise *of the sheet.*

Strength in pounds per square inch.	Point of fracture.	REMARKS.
53849	No. $1\frac{3}{8}$	A short portion only embraced in the space between the wedges.
53699	" $2\frac{3}{8}$	Do. Fracture near the gripe of the wedges. Short piece.
27604	" $7\frac{1}{4}$	Part in melted metal from 6 to $9\frac{1}{2}$. Compound of tin and lead used to float the standard-piece. Mean area of the sections of 7, 8, 9, and $9\frac{1}{2}$ is .180245. In order to ascertain the temperature required to break the bar with half the weight used in the preceding experiment, a calculation was made and this mean area found to require $174\frac{3}{4}$ pounds, which were accordingly applied. The standard piece rose a little way out of the melted metal just before fracture.
27602	" $12\frac{3}{4}$	Part in tin from 11 to 14 inclusive. This experiment was conducted so as to avoid loss, and may be regarded as, on the whole, rather preferable to the preceding in point of accuracy.
21919	" $17\frac{3}{4}$	In melted metal from 17 to 20 inclusive. When the fracture took place the bar had been extending rapidly for some time, and as the furnace was not lowered, would probably have broken with less weight.
21967	" $22\frac{1}{2}$	In metal from 21 to 24. Broke gradually by keeping down the heat and preventing an excess above what was actually necessary to continue the extension of the bar.
51947	" $6\frac{1}{2}$	This temperature was only judged of *approximately* on account of the heat imparted to the machine by the preceding experiment.
63307	" $5\frac{1}{2}$	Machine still warm.
55305	" $8\frac{1}{4}$	
45597	" $23\frac{1}{2}$	
53466	" $24\frac{1}{4}$	
53933	" $25\frac{1}{4}$	
52186	" $15\frac{1}{4}$	
45027	" $18\frac{1}{2}$	This part of the bar appeared very defective from flaws.
46906	" $19\frac{1}{2}$	

The mean area of the 15 sections of fracture is .000185 square inch *greater* than that of the 29 measured sections.

TABLE LV.

Experiments on bar No. 228. *Manufactured by Messrs. E. T. Ellicott & Co., of Baltimore. The mode of manufacture, source of the ore,*

Marks.	Breadth.	Thickness.	Area of section before trial.	Number of the experiment.	DATE.	Area of the section of fracture before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.
0	.762	.243	.185166							
1	.755	.244	.184220							
2	.758	.245	.185710		1834.					
3	.758	.245	.185710	1	Aug 6.	.186528	87°	266	7980	399
4	.762	.245	.186690							
5	.760	.242	.183920							
6	.758	.242	.183436							
7	.760	.246	.186960	2	"	.183436	87	287	8610	430
8	.759	.248	.188232							
9	.758	.248	.187984	3	"	.185710	87	305	9150	457
10	.752	.247	.185744							
11	.754	.244	.183976	4	"	.185710	87	367	11010	550
12	.754	.243	.183222							
13	.760	.243	.184680							
14	.762	.246	.187452	5	"	.187984	87	312	9360	468
15	.761	.247	.187967							
16	.762	.243	.185166							
17	.762	.248	.188976	6	"	.183222	87	317	9510	475
18	.762	.250	.190500							
19	.762	.246	.187452							
20	.755	.247	.186485	7	"	.187967	87	319	9570	478
21	.757	.252	.190764							
22	.754	.252	.190008							
23	.757	.248	.187736	8	"	.190500	87	340	10200	510
24	.757	.248	.187736							
25	.761	.249	.189489	9	"	.184730	85	342	10260	513
26	.760	.249	.189240							
27	.758	.245	.185710	10	"	.187475	85	359	10770	538
28	.754	.245	.184730							
				11	"	.187555	85	361	10830	541
	Mean of 29		.186748							
				12	"	.190008	85	361	10830	541
	Maximum		.190764							
	Minimum		.183222	13	"	.187736	85	363	10890	544
	Mean of these 2		.187493		Mean of 13	.186811				
	Diff. of the 2		.007542							

TABLE LV.

kind of pig-metal, &c. not stated. This bar cut crosswise *of the sheet.*
Specific gravity, 7.6675.

Effective strain.	Strength in lbs. per square inch.	Point fractured.	REMARKS.
7581	40643	No. 13⅔	The first permanent elongation was taken with a weight of 232 lbs. With 238, the extension was .146 inch on a length of 24 inches; but the recoil .046 when relieved from strain.
8180	44593	" 6	
8693	46809	" 3	
10460	56324	" 2	
8892	47302	" 9	The fracture took place with the weight first applied—the result is therefore supposed to be too high.
9035	49263	" 12	
9092	48370	" 15	Before this fracture was effected, the piece under trial (from 16 to 27,) had become 11½ inches long.
9690	50866	" 18	
9747	52763	" 28	
10232	54578	" 26½	
10289	54859	" 20¼	
10289	54150	" 22	
10346	55109	" 23	The mean area of the 13 sections of fracture is .000063 square inch *greater* than that of 29 measured sections.

TABLE LVI.

Experiments on bar No. 229. Boiler plate iron. Manufactured by Messrs. E. T. Ellicott & Co., of Baltimore. Origin of the metal, mode of manufacture, &c., not specified. Supposed to be "lamellated plate."

Marks.	Breadth.	Thickness.	Area of section before trial.	No. of the experiment.	DATE.	Area of the section of fracture before trial.	Temperature Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in pounds per square inch.
0	.766	.238	.182308		1833.							
1	.766	.240	.183840	1	Dec. 28,	.184601	58°	301	9030	451	8579	46473
2	.770	.240	.184800									
3	.765	.241	.184365	2	"	.183840	58	307	9210	460	8750	47595
4	.765	.241	.184365									
5	.760	.243	.184680	3	"	.184560	58	320	9600	480	9120	49415
6	.762	.240	.182880									
7	.763	.240	.183120	4	"	.182960	58	328	9840	492	9348	51093
8	.763	.240	.183120									
9	.762	.235	.179070	5	"	.183120	58	333	9990	499	9491	51283
10	.762	.235	.179070									
11	.758	.235	.178130	6	"	.179070	58	341	10230	511	9719	54275
12	.761	.235	.178835									
13	.764	.235	.179540	7	"	.178130	58	350	10500	525	9975	55997
14	.760	.234	.177840									
15	.760	.234	.177840	8	"	.177840	58	356	10680	534	10146	57028
16	.761	.237	.180357		1834.							
17	.762	.237	.180594	9	Jan. 18,	.186885	1159	168	5040	252	4788	25620
18	.765	.242	.185130									
19	.768	.242	.185856	10	May 31,	.180555	69.5	319	9570	478	9092	50356
20	.767	.245	.187915									
21	.762	.241	.183642	11	"	.185454	70	347	10410	520	9890	53521
22	.764	.235	.179540									
23	.765	.240	.183600	12	"	.186138	70	348	10440	522	9918	53571
24	.767	.243	.186381									
25	.766	.243	.186138	13	"	.186371	70	303	9090	454	8636	46212
26	.766	.243	.186138									
27	.766	.244	.186904	14	"	.185130	70	346	10380	519	9861	53265
27½	.763	.245	.186935									
28	.761	.246	.187206		Mn. of 14=	.183189						
Mean of 30 =			.183338									
Maximum=			.187915									
Minimum=			.177840									
Mean of the 2			.182877									
Diff. of the 2			.010075									

TABLE LVI.

This strip was cut in the direction across the sheet, reduced by filing from one inch in breadth and $\frac{1}{4}$ inch in thickness, to the dimensions given below. Specific gravity 7.7428.

Point of fracture.	REMARKS.
No $4\frac{3}{4}$	The first permanent elongation on this bar was observed under 210 pounds. Part in the machine from 1 to 12.
" 1	
" $1\frac{3}{4}$	
" $6\frac{1}{2}$	A different piece from that broken in the preceding experiment.
" 8	
" $9\frac{7}{8}$	
" 11	
" 14	The 1st, 3d, 5th, 6th, 7th and 8th experiments give a decreasing series of areas with an increasing breaking weight.
" $19\frac{1}{2}$	Part in hot metal from $17\frac{1}{2}$ to $20\frac{1}{2}$, loaded with half the mean weight required in the 8 preceding experiments.
" $22\frac{1}{4}$	
" $23\frac{3}{4}$	
" $25\frac{3}{4}$	
" $19\frac{1}{4}$	Short piece taken off by the wedges.
" 18	
	The mean area of the 14 sections of fracture is .000149 square inch *less* than that of the 30 measured sections.

TABLE LVII.

Experiments on bar No. 230. Manufactured by Messrs. E. T. Ellicott & Co., of Baltimore. The mode of manufacture, the source of the

Marks.	Breadth.	Thickness.	Area of the measured points before trial.	No. of the experim't.	DATE.	Area of the section of fracture before trial.	Temperature, Fah.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.
0	.760	.250	.190000							
1	.757	.252	.190764							
2	.759	.253	.192027		1834.					
3	.759	.251	.199509	1	June 28.	.190509	82°	330	9900	495
4	.756	.251	.189756							
5	.757	.251	.189907							
6	.755	.254	.191770							
7	.755	.255	.192525	2	"	.190373	82	330	9900	495
8	.753	.255	.192015							
9	.756	.255	.192780	3	"	.192270	82	334	10020	501
10	.755	.254	.191770							
11	.755	.254	.191770	4	"	.192846	82	340	10200	501
12	.755	.254	.191770							
13	.756	.255	.192780	5	"	.191268	82	348	10440	522
14	.758	.255	.193290							
15	.757	.254	.192278	6	"	.192780	82	354	10620	531
16	.757	.254	.192278							
17	.755	.254	.191770	7	"	.192278	82	354	10620	531
18	.757	.254	.192278							
19	.757	.254	.192278	8	"	.191833	82	361	10830	541
20	.755	.254	.191770							
21	.756	.253	.191268	9	"	.192024	82	363	10890	544
22	.756	.251	.189756							
23	.756	.253	.191268							
24	.757	.253	.190521	10	July 8,	.190521	75	404	12120	606
25	.757	.253	.190521							
26	.757	.255	.193035							
27	.757	.254	.192278	11	"	.192784	75	396	11880	594
28	.757	.254	.192278							
29	.757	.253	.190521	12	"	.191770	75	405	12150	607
Mn. of 30 p'ts meas.			.191584	13	"	.191770	75	405	12150	607
Maximum			.193290	Mean of 13=.191771						
Minimum			.189756							
Mn. of these 2			.191523							
Diff. of the 2			.003534							

TABLE LVII.

ore, the kind of pig-metal, &c. not specified. This bar was cut lengthwise *of the sheet. Specific gravity* 7.6675.

Effective strain.	Strength in lbs. per square inch.	Point fractured.	REMARKS.
9405	49368	No. 3	First permanent elongation taken with 196 lbs. Under 320 lbs., 26 inches had become 28.1, and after the fracture, the part from 3 to 25 was 24 inches long. When the strain by 317 lbs. was removed the recoil on 24 inches was 1–20 of an inch.
9405	49409	" 5¼	The laminæ are now distinctly visible along the edge of the piece broken off, showing marks of *piling* or lamellation.
9519	49508	" 7½	
9699	50294	" 26¼	
9918	51849	" 21	After this fracture, the part from 10 to 20 measured 11 inches.
10089	52334	" 9	
10089	52471	" 15¼	
10289	53719	" 17⅛	
10346	53879	" 19½	
11514	60434	" 24½	The piece now under trial, from 21 to 26½, had been exposed to a strain of 386 lbs. for more than ten days, but showed no signs of yielding.
11286	58542	" 14½	This fracture took place almost within the gripe of the wedges.
11543	60192	" 10	
11543	60192	" 12	

The mean area of the 13 sections of fracture is *greater* by .000187 square inch than that of the 30 measured sections.

TABLE LVIII.

Comparative table showing the relative advantages of different modes of manufacturing boiler-iron as deduced from preceding tables.

Compar.	Process of manu.	Bars tried at original sections.			Bars tried at deeply filed sections.			Bars reduced to a uniform size by filing.			Names of the Manufacturers.
		No. of the bar.	Strength of each bar.	Mn. st'h. of the sets.	No. of bar.	St'gth of each bar.	Mean strength. of sets.	No. of bar.	Strength of each bar.	Mn. st'h. of the sets.	
1	Piled iron.	2 } 5 4 }	52.421		2 }	63.266		3	56.081		Mason & Miltenberger.
		6 }			5 }						
		8 }	53.670	53.045			63.266			56.081	
2	Piled.	25	46.079								Shorb.
		27	55.636								
		30	44.703								
		32	52.197								
		35	43.237								
		37	46.155								
		39	40.595								
		41	37.713	45.914							
3	Piled.							226	52.090		Evan T. Ellicott.
								227	53.774		
								228	50.433		
								229	55.774		
								230	54.014	53.217	
4	Piled.	242	59.247	59.017							Valentine & Thomas.
		243	58.787								
5	Hammer'd plate.				9	67.211		14	57.840		Spang & Son.
		9	58.243		10	64.511		16	56.891		
		11	46.126		11	55.529					
		17	44.249		13	50.908					
		18	50.218		15	50.166					
		21	39.578		22	59.372					
		23	44.289	47.117	23	62.646	58.620			57.365	
6	Hammer'd plate.	78	43.006		75	60.433		88	53.803		Schoenberger.
		81	51.318		83	56.046					
		83	49.239		85	60.440					
		84	45.443		86	62.156					
		85	51.606		90	52.301					
		87	51.287								
		90	43.365	47.895			58.275			53.803	
7	Hammer'd plate.	46 }	59.904					49	59.607		Blake.
		48 }									
		51	61.091								
		53	56.477								
		68	61.127								
		70	47.638								
		71	64.823								
		73	52.657	57.676						59.607	
8	Puddled iron.	42	52.413		56	58.964		74	51.039		Blake.
		44	54.718		58	70.938					
		56	57.926		60	60.907					
		58	53.112		62	58.376					
		59	48.308		65	62.917					
		61	55.904								
		64	45.092								
		65	51.255	52.341			62.420			51.039	

Strength of Boiler Iron Manufactured by Different Processes.

In making a comparison for determining this point, it was necessary to distinguish those experiments, which were made on the strips as they came from the shears, from those which were performed on deeply filed sections, as well as from those in which the bars had been reduced to a uniform size.

It is proper to observe, that the inherent irregularities of the metal, even in the best specimens, whether of rolled or hammered iron, seldom fall short of ten or fifteen per cent., of the mean strength.

Thus, of the bars referred to in the preceding table, No. 22 exhibits an irregularity of 19 $\frac{3}{10}$ per cent.; No. 23, 29 $\frac{3}{10}$. No. 90, 24; No. 230, 20 $\frac{8}{10}$, and No. 228, 31 per cent. of the mean strength. These two last mentioned bars had been reduced to an uniform size and were entirely broken up at ordinary temperatures, chiefly with a view to the degree of uniformity of strength.

It will be seen, on inspecting the preceding table, that of all the kinds of iron here presented, the piled iron of Mr. Shorb proved most defective in strength; some specimens of that kind, exhibiting but little more than half as much tenacity as the best boiler iron which came under examination. Nos. 39, and 41, in particular, were found to possess extensive unwelded portions between the several laminæ of the plate.

These developed themselves to the distance of several inches when subjected to the action of the machine.

In comparing the two kinds of iron manufactured by Messrs. Blake & Co. we find that the kind produced from blooms, and denominated hammered plate, is superior by about 13 per cent. to that manufactured by puddling.

It will be observed that of the eight sets of results embraced in table LVIII., four, viz.: Nos. 1, 5, 6, and 8 afford the means of comparing together those trials which were made after all the three modes of preparing the bars.

No. 1 gives to the rough bars a strength of 53045; to that which was reduced to uniform size, 56081, and to those filed in notches on the edges, 63266. In a similar manner finding for the other three sets their mean results, we have for bars tried as they came from the shears, mean of four sets, 50099 lbs; reduced to uniform size, 54572; for those filed on the edges, 60645.

(TO BE CONTINUED.)

Observations on the duty performed by the Cornwall Steam Engines. By Jacob Perkins, Civil Engineer.

Read before the Institution of Civil Engineers, London, February 16th, 1836.

TO THE EDITOR OF THE JOURNAL OF THE FRANKLIN INSTITUTE.

Dear Sir—I herewith transmit for your examination, and for insertion in your Journal, should you think proper, a series of three papers, upon the duty performed by the Cornwall steam engines. Yours, &c., J. Perkins.

The true cause of the great difference of duty performed by the Cornwall and the best Boulton & Watt engines, has been a matter of serious inquiry for the last fifteen or twenty years. But within the last two or three years the difference has been so astonishing as to induce many engineers to suppose that some part at least was owing to trickery.

If we do not admit the fact of the superiority of the Cornish engines, the cause will not soon be found. I must say that after much thought, investigation, and experiment, I believe that the Cornwall Engines do at least three times the duty that the best low pressure, condensing, double stroke engines do; and I have no doubt that I see the reason of it.

Having, in the first place, visited the Cornwall Mining establishments to judge for myself, I very soon came to the conclusion, that the advantage which the Cornish single stroke engine has over the reciprocating double stroke engine is much more owing to the difference in the construction of the engines, than in that of their boilers. Very few engineers know the great value of using high steam expansively, and many of those who admit it, do not know how to apply it properly.

The repeated experiments which I have made have satisfied me that the single stroke engine is far better calculated for taking advantage of the valuable property which the expansion of high steam possesses than the double stroke. In the first place, there should be no steam lost between the steam-pipe and piston, which cannot be avoided in a double stroke engine. In the second place, at the end of the stroke the steam should be allowed to escape without any reaction, and this cannot take place, when the induction and eduction pipes are used at each end of the cylinder, as is the case with the double stroke engine.

If the induction pipe is large enough to allow the steam to escape freely so as to prevent loss by reaction, then the eduction pipe would be much too large for the induction pipe, and much high steam would be lost, without having the benefit of expansion. In fact, it is impossible to get the steam on and off soon enough in the double stroke engine. The loss from this cause is much greater than is generally believed. It is supposed by some that there is a loss by having the steam on one side of the piston only; it is, however, quite the reverse. It is very well known that the larger the piston the greater is the saving, particularly in the piston itself. To make the single stroke engine consume the same steam as a double stroke engine, the cylinder must be double the area.

If it should be said that much time and power is lost by not having the steam on the piston on the return stroke, it may be said in answer, that if only fifteen strokes are made in a minute, there would be but two seconds between the working strokes; and that the fly, when the fly is used, must be very light indeed to show any variation of speed. When worked in the Cornish fashion, without the fly, no power can be lost between the strokes.

I do not mean to say, that all the gain is to be attributed to the single stroke engine, there is undoubtedly much power saved by dispensing with the fly wheel, where the work to be done is pumping water. This is proved by the fact, that a single stroke, balance bob, low pressure, pumping engine will raise 33,000,000 lb.; while the double stroke low pressure engine with a fly-wheel will raise but 22,000,000 lbs. The fly, is a power which will not, like steam, wait to accommodate itself to the stubborn visinertia of the water, neither will it accommodate itself to the going off of the steam, consequently much power must be lost. When one watches the beautiful accommodating action of the Cornish pumping engine he will readily see, that there must be great loss in using the ponderous fly. When the steam is first let on to the piston, the pressure, although 40 lbs. to the square inch, it seems too little for its work, and appears to labour hard to get the water in motion, but at the end of the stroke, although the steam has expanded down to 10 lbs. to the inch, the work seems quite light. Here the expansive property of high steam is beautifully exemplified. To begin the lift 40 lb. to the inch seems not enough, but when the stroke is ended, 10 lbs. seems more than is wanted. How is it with the condensing double stroke engine? Is not the power the same at the end of the stroke as at the beginning?

I cannot believe that the enormous quantity of 125,000,000 of water was

raised one foot high with 84 lb. of coal without the assistance of a little air, which certainly can be used without being readily detected. To show how I learnt this singular fact, I must be allowed to relate a curious trick which was attempted to be passed off on me in America about forty years since. Two honest farmers, one day called on me to see if I would join them in a patent of great importance; they stated that the discovery would prove that the law was erroneous which stated that water would rise only about 32 feet in a vacuum. I told them that it was contrary to what I had learnt and declined having anything to do with it; they, however, would not be put off. They said that they had brought with them an exhausting pump, which had raised water 100 feet by rapid exhaustion, and that they would pay all the expenses of fitting it up, and that I could then see who was wrong. One of them averred that he was a ruined man if he had been deceived. I was so satisfied that he had been imposed upon that I readily agreed to test his pump. I had a leaden pipe attached to the double barrelled exhausting pump, and the situation I had fixed upon happened to be 44 feet from the water to the pump. When the pump was put in action, it, to my great surprise, delivered the water at the pump spout. I then set myself to work to discover the cause, which was not ascertained until the third day; I observed that the water appeared full of air bubbles, it then struck me that air was allowed to mix with the water in minute portions, by which means the column of water became expanded; I then placed my ear close to the pipe and soon discovered a singing noise, and by clasping the tube with my hand the noise stopped and the water ceased to flow. Here was the trick; by examining the tube I found that it had been perforated with a small pin-hole unknown to me, which admitted just air enough to expand the column. I then charged the men with the imposition, one denied it, but the other looked pale, and acknowledged he had done it by the direction of the inventor, who said that it must be kept a secret, otherwise the invention would be infringed upon. They were now made to understand that they were duped, and were soon on their return home, minus 3000 dollars.

Having seen that a column of water might be expanded by admitting air under the lower clack, I was induced to inquire, while in Cornwall, of an Engineer, if he had ever known air to have been admitted under the clack; after expressing his surprise at my question he admitted that it was common, but that it was not acknowledged, since every one wished to have it appear that they had done as much duty as possible.

Since the quantity of water pumped was known by the number of strokes per day, and as the contents of each stroke was known by its length, and by the diameter of the plunger, if the air which the water contained was not allowed for, more work appeared to have been performed than had actually been done.

My friend stated that it had been found advantageous to allow air to be admitted in small portions, for it made the pump work more lively in consequence of the spring it gave to the column of water and caused less strain to the machinery, but that he never knew the air allowed for. Although this circumstance of admitting air to mix with water serves to lessen the amount raised, yet this cannot, I think, be more than 15 or 20 per cent., and I fully believe 90,000,000 lbs. have been raised one foot high by a bushel of coal.

The following statement, extracted from the London Journal of Arts and Sciences, of July 1st, 1827, of a series of experiments which were made at Saint Catherine's Dock about ten years since, with a high pressure single stroke expansive engine, I think conclusive.

"We have the pleasure of announcing that Mr. Perkins has at length, in a very satisfactory manner, proved the superiority of his newly constructed high pressure steam engine, by working it against two other steam engines upon the low pressure principle.

" This small engine, which we have several times mentioned in our present volume, has been within these few days set up at Saint Catherine's Dock, and employed in pumping water from the excavation.

"There have been four steam engines engaged in the prosecution of these works, two for excavation, and two for pumping out the water; Mr. Perkins' engine stands alongside a low pressure engine of sixteen horse power, which is determined by the area of its piston.

"The diameter of the piston, that is the bore of the steam cylinder of the new high pressure safety engine is eight inches, and its stroke twenty inches. It was connected by gear to a beam that made sixteen vibrations per minute, and raised two alternating pump-buckets, the diameters of which are fourteen inches, and their strokes three feet three inches.

"We, the undersigned, certify that there are two low pressure steam engines employed night and day in discharging the water which flows into Saint Catherine's Dock from the Land springs, &c., that one of them is a sixteen and the other a ten horse engine. We also certify that Mr. Perkins has recently put up a small high pressure steam engine the diameter of whose piston is eight inches, its stroke twenty inches, and that we have seen this engine pump the same quantity of water from the Docks which has heretofore been pumped by the other two.

James Lamon,
Pearson Woodward,
Thomas Brown.

"I, the undersigned, certify that I have superintended and put up Mr. Perkins' high pressure safety engine. I also certify that what is stated by the above Engineers is true, and that it was done with only 42 lbs. of coal per hour. Having been engaged twenty two years in making and putting up engines, principally in Cornwall, it is not likely that I could be deceived as to the power and efficacy of this engine, and I conscientiously believe that two-thirds of the coals used in this country might be saved by the use of this engine.

Henry Hornblower.

"I, the undersigned, carefully weighed the coals and placed them under Mr. Perkins' generator, that 42 lb. weight of coal only was used per hour. I also certify that what is stated by the above Engineer respecting the work done is true.

William Hearne.

"Mr. Perkins is of opinion that the two low pressure engines could not have been worked up to their full power, although they used the full quantity of coals, three and a quarter bushels per hour; but admitting they worked at only two-thirds of the power, there would be a saving of about three-fourths of the coal consumed in low pressure engines, by the employment of Mr. Perkins' new principle."

In the above experiments the difference in favour of my single stroke high pressure expansive and condensing engine was quite as great as that which exists between the Cornish and the Boulton and Watt engines. Does not this prove that the enormous gain is chiefly owing to the great superiority that the single stroke, high pressure expansive and condensing engine, has over the low pressure, double stroke, condensing engine?

Not long since John Taylor, Esq. published an account of a great improvement which had been recently made in Cornwall. He stated that a single stroke, high pressure, exhausting engine, had been converted into a rotary engine, and that it was greatly superior to the double stroke engine, so much so that it astonished every one who witnessed its power. I could not at first comprehend what he meant by converting a single stroke engine into a rotary one. I finally concluded that a fly wheel must have been substituted for the accommodating balance bob used for pumping in Cornwall. This conjecture I have since found to be correct.

Whether the engine uses the steam on one or both sides of the piston, they are both undoubtedly reciprocating engines, and are called by that name.

That the single stroke engine, worked by high steam and expansively, is a very great improvement, the above mentioned experiment fully demon-

strates. The fact is, that the higher the steam can be practically used, and the sooner it is cut off, the greater is the economy.

I should mention that at the time these experiments were made at Saint Catherine's Dock, I had not overcome all my practical difficulties, for the generators would fur up and then burn out. I, however, had no reason to despair, for although the cost of wear and tear of the generators was greater than the common boilers, yet the saving otherwise was far greater. I have, however, recently been so fortunate as to remove all objections, by a new modification of the generators. I have good reason to believe that a voyage might be made to India and back without finding the boiler in the least foul, or perceptibly fire worn.

I have not a doubt that two single stroke, high pressure, expanding engines, might be used to great advantage in steam-boats, and that the time is not distant when it will be more economical for merchantmen to navigate by steam than by wind. It will undoubtedly be said by some that the power so applied would be too unequal. If a more equal, or rather continuous, power is wanted why do not the barge-men of the men-of-wars gig, have some of their oars always in the water.

I have often been asked, why I did not follow up the patent, if I was satisfied that there was no fallacy in the result of my experiments. My answer has been, that very soon after I had completed those experiments my monied partner failed and died, and his creditors put the patent in chancery, where it now remains, and I was obliged to turn my attention to other means to obtain a living.

When this experimental engine was worked with steam at a pressure of between 300 and 400 lbs. to the inch, I believe the induction valve was not opened more than about $\frac{1}{16}$ part of the stroke, if so, the annexed diagram will show the great gain.

Let Figure 1* represent a steam cylinder divided into 16 parts. Let the steam at 200 lbs. per inch be admitted at the dead point. Now fill the first division, No. 1, then let the steam be cut off and it will at that point be 200 lb. to the inch, next let it expand to No. 2, it will then be at 100 lbs. the mean will be 150. Again let it expand to double its space and it will occupy two of the divisions and leave off at 50, the mean 75 lbs., which amount to another 150 lbs. In expanding to 4, it will leave off at 25 lbs., the mean $37\frac{1}{2}$, the 4 divisions at $37\frac{1}{2}$ will give 150 lbs. more; after expanding down to 16 it will be only $12\frac{1}{2}$.

If the steam had been let into the cylinder at $12\frac{1}{2}$ lb. per inch and continued so until the cylinder was filled with steam at that pressure, then the work done would be equal to 200 lbs., amounting to just the same weight of steam when at 200 lb. to the inch in the first division, although the piston had made only $\frac{1}{16}$ of its stroke, the other $\frac{15}{16}$ of the stroke which was acting expansively, was clear profit.

It will be seen by diagram, Fig. 2* that although the steam on the piston is but $\frac{1}{16}$ part of the stroke, yet it was acting $\frac{1}{8}$ of the time; but what is the difference in the virtue of the two? it is as 800 to 200. This I do not say is mathematically correct, but I believe it to be near enough to give a pretty correct idea of the great practical advantage of using steam expansively if properly applied. Great credit is due to Hornblower, Trevethick, Wolf, and Evans the fathers of high steam. They elicited the spark which has since thrown such a lustre over the science of steam.

* Not forwarded, but see Vol. 4, p. 24, first series of this Journal.

If I have done any thing in the advancement of high steam, it is in consequence of witnessing the experiments of my countryman, Oliver Evans, the father of high steam in America.

The Editor has received the foregoing, from his friend, Mr. J. Perkins, together with two other papers upon the same subject, which will appear in the next number. He has also, from the same gentleman, some remarks upon steam engine explosions, controverting certain deductions made by the Committee of the Institute in their report upon that subject, which shall also appear, together with extracts from a letter which accompanied these papers, but which could not be prepared in time for the present number. The letters and papers were delivered to the care of a gentleman, coming to this country, nearly twelve months since, but, from accidental causes, they have but just come to hand.

Remarks on the protecting duty upon Iron.

TO THE EDITOR OF THE JOURNAL OF THE FRANKLIN INSTITUTE.

The importance of promoting and securing the production of iron in our country, and many of the manufactures connected with it, must be admitted as essential to our prosperity in peace, and safety in case of war. On this principle our protective laws in regard to iron are based, and cannot be repealed without a departure from the most obvious good policy. The admission of any foreign article, free of duty, has, with a due regard to this policy, been limited to such, as evidently could not conflict with the interests of the home manufacture. Such, for instance, was the case of rail-road iron, which could not be furnished at home, in quantity, at all commensurate with the demand, nor of the inferior quality of iron made in England for that purpose, and which could be imported (free of duty) at about half the cost of American. Of this measure, therefore, there is no occasion to complain; but what shall be said of the fact—that under *this* law manufactures of iron are admitted, which are fairly subjected to the duty? An instance of this kind may be found in the article of "Turning platforms for Locomotive Engines," which are *machines* placed, not *upon*, but *under*, the rails of rail-roads, and on no principle more entitled to be free of duty, than the locomotive itself. The effect of this, perhaps not solitary instance of the misapplication of the repealing law, I will now attempt to illustrate:—Before the late advance on prices of iron, say previous to 1836, the cost of engine platforms in England was £26 sterling each,

at $4 80 is,	124 80
Add for commission, freight and charges 10 per cent.	12 48
Cost, free of duty, - -	137 28
Duty 25 per cent., - -	34 32
	171 60
The same article could be, and was made in this country then at - - -	160
Less than imported with duty, -	11 60
More than imported free of duty, - -	22 72

To show the bearing on the home manufacturer, let us suppose he *imports* his materials:—for a Locomotive would be required,

1¼ tons Pig-iron—duty thereon at $10, is	12 50
4 cwts. rolled chain and bar-iron, at 1 50, is	6
He pays to Government,	18 50

for materials whereupon to exercise his industry, while the foreign mechanic makes the same article and sends it here, *duty free*. So much for the protection of Domestic Industry.* Should it be alleged that the manufacturer ought to use American iron, I reply that the British market regulates and controls the price of all iron here, so that it is the same thing to the manufacturer which he uses. But should *Iron Masters* be deprived of protection, such are the peculiar facilities in Great Britain, that the production of iron must cease here immediately, and the country be rendered dependent on foreign supplies for an article of the first necessity. ***

Franklin Institute.

Report on the Stone of Leiper's Quarries.

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred the communication from Messrs. Geo. G. Leiper, Wm. J. Leiper, and Sam. M. Leiper, requesting an investigation into the quality of the stone of the quarries on Crum Creek, and particularly the durability of its materials, REPORT,

That a sub-committee of seven members proceeded to the quarries on Crum Creek, in Delaware county, on Wednesday the 3d instant, for the purpose of making such examination as might serve for the basis of a report.

The quarries examined were Leiper's Lower Quarry, Hill's Quarry, and Leiper's Upper Quarry.

They are all of the Gneiss formation, dipping at various angles to the north-west, the direction of the strata being a few degrees west of north, and east of south. The Gneiss has an average specific gravity of 2.68, and is composed of quartz, feldspar, and mica, in variable proportions. The mode of aggregation of these ingredients is also variable. In the upper quarries, the mica is more regularly stratified, thus enabling the workmen to split off blocks of uniform thickness, admirably adapted for curb-stones and building materials, for which they have been extensively used in Philadelphia and its environs, and have given general satisfaction.

In the lower quarries, the micaceous portions are more irregularly situated with regard to the other constituents, giving the rock a more irregular fracture. The rock in this quarry is harder than the former, owing to the feldspar being more perfectly crystalline, and consequently less liable to decomposition. From these circumstances it is evident that the rock in the Crum quarry is better suited for hydraulic architecture.

Hill's quarry adjoins Leiper's lower quarry, and seems to be a continuation of it; but it differs from both the other quarries in having a larger proportion of mica, and of a darker colour.

Judging from the composition of the rocks, and from the opinion of competent engineers, builders, and masons, the Committee would pronounce,

* This statement is based on prices in 1835, because I know not the cost since iron has advanced; but the result will be in the same proportion.

without hesitation, that for all works to which they have been applied in and near Philadelphia, a better material could not be desired.

The materials of the Fairmount dam are of a similar rock, from other quarries, and to them no objection has ever been made. The Sub-Committee inspected, at Leiper's Mills, a fore-bay made of stone from their quarries, and which has been exposed to the action of water for a period of seventy years, and now appears uninjured, the marks of the chisel being still visible.

The Committee will confine their further remarks to the consideration of the liability to decomposition of the constituents of Gneiss rock, and particularly of the mica, which has been made the special ground of objection to the use of this rock.

First, it is universally admitted that the *quartz* is indestructible by any of the great natural agents.

It is not so with the *feldspar*, which is sometimes decomposed, by exposure to the elements, from the loss of its potassa.

As to the alleged destructibility of the *mica*, the following facts would seem to be conclusive.

If we examine the materials arising from the disintegration of the gneiss rock, we shall find them to be a sand, composed of quartz and mica, the feldspar alone having disappeared.

Some of the older sand-stones were composed of quartz and mica, cemented by an argillaceous and ferruginous matter, and containing an abundance of marine organic remains. It appears, then, that the quartz and mica are the more indistructible ingredients of the primary rocks, and that both are capable of resisting the decomposing action of sea-water, for a lengthened period of time.

Even in some of the more recent sand-stones, the same materials are observed under similar circumstances: a fact which strengthens the former conclusion respecting the indestructibility of the quartz and mica. In all these cases, the feldspar not appearing, we conclude that it has been decomposed.

The only authority, for the destructibility of mica, presented to the Committee has been drawn from the work of Prof. Cleaveland, where it is asserted that "Mica is subject to decomposition by exposure to the atmosphere, and is sometimes converted into a kind of steatitic matter." Of the manner in which Prof. Cleaveland supposes this to be effected, he speaks afterwards, when treating of granite, where he says, after mentioning the decomposition of feldspar, "the mica also, when exposed to the air, is subject to alteration or even decomposition:—sulphuret of iron, which is sometimes disseminated in granite, furnishes, by its own decomposition, sulphuric acid; and this acid acts upon the mica in its vicinity, thus producing a soft substance resembling steatite, and diminishing the firmness of the granite."

The Committee consider the assertion of Prof. Cleaveland, and his explanation, as equally doubtful. They have never observed any such change as he mentions, and it is a well known chemical fact that mica is not soluble in sulphuric acid. Moreover, the assertion of Prof. Cleaveland will apply only to rocks containing iron pyrites, and then only to such rocks when exposed to the air, for pyrites is not decomposed under water.

Indeed, Prof. Cleaveland must not be supposed to assert that mica, under ordinary circumstances, is decomposible by exposure to the action of the elements. That such cannot be his opinion, and that such is not the

fact, a most striking evidence may be adduced from his Treatise on Mineralogy.

After speaking of the existence of mica in primitive rocks, he goes on to say:—"Mica also occurs in green-stone, basalt, sand-stone, and other secondary rocks, especially in the sand-stone and shale which accompany coal. It is abundant in the sand of primitive countries, and exists even in that which is far distant from primitive rocks. It is often connected with volcanic rocks. But, notwithstanding this universal diffusion of Mica, it has most probably, in all cases, been formed among primitive rocks. Hence, when found in secondary rocks, or alluvial earths, it has undoubtedly arisen from the disintegration of primitive rocks, and been subsequently transported by water."

(By order of the Committee.)

WILLIAM HAMILTON, *Actuary.*

Philadelphia, March 9th, 1837.

Progress of Practical and Theoretical Mechanics and Chemistry.

On the Manufacture of Whim Ropes from Iron Wire.

(Being the Substance of a Communication from Mr. Albert, of Clasthal Royal Britannic Hanoverian Mining Councilor, to Dr. Karsten, Royal Prussian Privy and Mining Councillor, and Member of the Royal Academy of Sciences in Berlin, Editor of the "Archives of Mineralogy, Mining, Metallurgy," &c.)

(From the "Archiv fur Mineralogie, Geognosie, Bergbau und Huttenkunde," conducted by Dr. C. J. B. Karsten. Berlin, 1835.)

The great annual expense of providing ropes for the shafts in the mining district of the Upper Harz, and the circumstance of the hemp being only procurable by importation from abroad, led me during several years to make a series of experiments for the sole application of iron to this purpose. These experiments terminated in new methods of manufacturing whim-ropes, and of obviating their weight, by the adoption of endless chains; but yet my object was not accomplished. However, it occurred to me subsequently, at the commencement of last year (1834.) that iron wire might be plaited or twisted together so as to form a whim-rope; and the results of my experiments were so completely satisfactory, that arrangements are now making in these mines for the general adoption of ropes of this description. The manufacture of them from iron wire is, in fact, a very simple, and not an expensive operation; and yet there are a great many apparently insignificant circumstances which materially delay the work, and occasion impediments, which can only be obviated by obtaining an accurate knowledge of them. I have, therefore, resolved to describe the process and its peculiarities, and hope thus to render some service to practical science.

In the first place, the iron wire employed is of the sort numbered 12, in the Royal Foundry of the Harz, of the diameter 0,144 inches; and ten feet of the wire weigh 13,91 Loth, Cologne weight, or seven and one-fifth ounces avoirdupois.

This wire is drawn by a machine, in lengths of 60 to 130 feet; and to facilitate the work on the straight-rope course, and to avoid weakening the wire by violent bending, in order to bring it into a straight direction, it is so

arranged, that after the last heat, the drawing is performed with a single wire on a cylinder of twelve feet in diameter. The price of this wire is at present 9 dollars, 10 groschen current, for 110 lbs. Cologne, or about 1*l.* 7*s.* per cwt.

For the preparation of the wire, the following implements are requisite:

1. A large smith's vice, about 70 lbs. in weight, attached to a frame of the usual height.

2. A small hand-vice, about 6 lbs. weight.

3. Iron winches (*fig.* 1) made of one piece, three-eighths of an inch thick at the middle, with a round handle at each end, altogether fifteen inches long. The centre forms a flat surface, containing five holes of about three-tenths of an inch diameter. The four outmost holes lie in a circle at one and a quarter inch distant from each other. At the centre of the circle is a similar hole, connected with the other holes by grooves of about one-fifth of an inch in width. This communication may be suspended by means of pegs, introduced through small openings on the narrow side of the winch, pushed before the holes, and fastened by their elasticity, or if required, by grooves made to fit. The holes must have no sharp edges. If despatch is required, three such winches will be necessary.

Fig. 1.

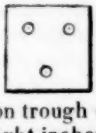
Fig. 2.

4. An iron winch (*fig* 2) of the same construction as the former, with this difference, that it contains only three holes of half-inch wide, without connexion with each other.

5. About eighty boards, of six inches square, half an inch thick, with four round holes of one-quarter inch wide, two inches apart in the square (*fig.* 3.)

Fig. 3.

Fig. 4.



6. About ninety similar boards of hard wood, with three round holes of half-inch wide, at equal distances from each other (*fig.* 4.)

7. A cast-iron trough one-quarter of an inch thick, three feet long, ten inches wide, eight inches deep, and about 60 lbs. in weight, or a similar one of plate iron.

8. Some files for sharpening the ends of the wires, knippers to take off the ends, and pliers to lay on a thin band of wire at particular parts of the chain.

Method of manufacturing the rope.—The work requires a covered walk at least 130 feet long. The wires are laid in a straight line one beside the other, and the ends sharpened with the file before they are applied to the holes. Four wires are fastened to the large vice at the end of the walk, previously to which thirty or forty four-holed boards, and behind them the four-holed winch (No. 3) have been pushed along them, the boards being arranged at the distance of three or four feet from each other, to prevent one wire from touching the other. Along the whole length of the walk, workmen stand at six to ten feet apart, holding the wire up, when trussels or props are not provided, and turning it with a uniform and constant motion. With the length above supposed, about ten persons would be required; although a machine is now being made for the purpose; which will, however, only be advisable when a large number of ropes are to be prepared. At the end of the walk, opposite the vice, a trusty workman is placed,

to keep the ends of the wire constantly separate while they are being turned. At the vice two men are stationed; the one turns the iron winch (No. 3) in such a manner, that at every complete revolution of the winch he advances six inches forward. At first this distance may be regulated by measurement, but in a short time practice gives the necessary correctness.

The second workman at the vice follows the turner with the small hand-winch (No. 2,) secures in it the twisted rope at every two feet, and holds the winch steady, so that the turner can advance further.

As the turner proceeds, the boards (No. 5) are pushed towards the other end, and the workmen as they reach it successively, are for the time no longer required; as often as the winch is turned once round, so often all the four wires must be turned throughout the whole length of the rope; but during this turning no twisting takes place, but only a motion upwards and downwards, as well as from left to right.

When the turner has proceeded with his work to the end of the walk, and a cord of four wires is thus completed to the above length, this cord is for the present laid on the ground. The workmen who have been spared, as above described, have meanwhile provided the wires intended for the second cord, with the dividing boards (No. 5.) and after them with the second winch (No. 3.) The four wires are then inserted in the vice, the turner recommences his work as before; and after that a third cord of four wires is formed by the same process.

It will be requisite to make one of these three cords considerably longer than the others, and the last is preferable for that purpose, as the turning winch (No. 3,) and the boards (No. 5) can then be put on at once, so that the turning is not meanwhile delayed. When the three cords of the length of the walk are completed, they are then turned together to form the main rope, the ends of each cord being now put through the ninety boards (No. 6,) which are pierced with three holes, the second turning winch with three holes, (No. 4) is put on, and the ends of all the three ropes are at once attached to the main vice (No. 1.) The workmen are again distributed along the walk, and the turning proceeds as at first; yet, with this important difference, that as soon as two feet of the rope are turned, the main vice is opened, and the whole of the workmen move two feet forward in that direction, and the finished rope, as it becomes longer, is rolled behind or beside the vice in the form of a coil or ring, at least nine feet in diameter. For this operation a cross is placed on the ground, so as to be easily turned round, formed of two strong pieces of deal *(fig. 5)* resting on a pivot in the centre. After thus completing a rope of three cords and twelve wires, it is lengthened by repeating the same process, when the single wires are to be joined to those of the next rope.

Fig. 5.

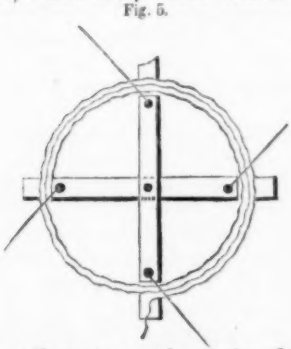


Fig. 6.

After many trials, I have found it best to unite them by means of friction, in the following manner:—on working to the end of one wire, a new one is inserted into the same holes of the boards, (No. 5) along with it, so that at the ends of the wires which are nearly worked off, two wires always lie

together for the length of forty inches. When the turner arrives with the winch (No. 3,) at the commencement of a fresh wire, he thrusts it into the centre hole by the sharpened point, and almost into the middle of the four turned strands of the rope in progress, where it is fastened by binding it round a few times with thin wire, mainly for the purpose of ascertaining at any time where the end of a wire is to be found, since it is desirable to bring it, if possible, to the inner part of the main rope, when the latter is to be turned. The rope is then turned twenty inches farther, in such a way that the fresh wire remains firmly seized in the middle of the former. The corresponding peg of the two in the winch (No. 3) is now drawn out, the wire which is nearly worked off is pushed out of its hole in the circle of the winch, and inserted into the centre hole of the same winch; and in its place the forward end of the fresh wire is removed from the centre hole, and inserted into the vacant hole in the circle, when the peg is again pushed forwards.

On continuing the turning, the remaining twenty inches of the old wire likewise occupy the centre of the rope, and are again bound round at the ends with thin wire. The firmness of this binding consists in the circumstance that every wire in the main rope or chain is not exposed at the exterior surface for more than from six to nine inches; as it then enters the interior, where the tension retains it firmly in its position, even although a single wire at the surface should occasionally be worn away or otherwise rendered useless. The marking of the places where the ends are fastened by the thin wire, enables the workman to distribute these fastenings in an equal manner through the rope, which indeed often takes place of itself from the irregular length of the wires, and is often effected by the breaking of the single wires. There should not be more than two ends of different ropes at the same point.

By the method described, a rope of any length may be made, adapted to the depth of any particular shaft. If the covered walk be 130 to 140 feet long, thirteen workmen will be wanted, who may be kept fully employed; of these, five or six must be men on whose care reliance may be placed; the others may be invalids or boys. On an average, these thirteen persons in one hour can finish fifty feet of rope, at least.

The rope when completed must be covered with an adhesive composition, which on cooling still remains *flexible*, in order to defend it against the damp of the mines. For this purpose there may be used the refuse of artificial grease or oily composition; and in default of these, a mixture may be employed, consisting of one-third of oil, and two-thirds of colophonrium or rosin. The iron trough (No. 7) is filled with this composition, and a coal fire maintained under it till it becomes heated to the temperature of boiling water; the rope is then drawn slowly through it, so that it may become sufficiently heated in the fluid, and all the interstices become filled with the grease, and consequently devoid of air. In an hour and a half 700 feet may be thus greased by eight workmen. When many ropes are to be made, a machine may be employed for this purpose, which, however, would produce no saving, if the work be on a small scale. To 700 feet of rope, there will be required forty to fifty pounds of the composition.

To join the rope to the chain on which the bucket hangs, I have found the following to be the simplest method:—The end of the rope is heated gently, to the length of eight inches, and then bent round an iron clamp, in the form of the half of a chain link, hollowed from beneath (*fig.* 6.) A wrought-iron ring, of one inch in breadth, previously drawn along from the

opposite extremity of the rope, is then driven down to the clamp, and the ends of the wires are separately turned through the ring, and fastened or beaten down over it, after which the whole is fastened with wire or strong cord round it; or if greater security is desired, it is enclosed in molten lead. A chain-link is suspended in the grooved clamp before closing the chain, or it may be done afterwards, if a snap-link be employed, which may be opened and shut.

As long as this process presents no manifest disadvantages, it will not be requisite to adopt any superior or more difficult methods. The heated part of the rope should not extend upwards above the ring. After various trials the weight of a rope of 700 feet, without the composition, was found to be only three cwt. one quarter, or from three to four pounds every seven feet. The expense, on a close calculation, for manufacturing a rope of 3920 feet, including every outlay, to the time of fixing it to the whim, is 220 dollars, namely, 171 dollars for the wire, and 49 dollars for wages, or about 31*l.* 10s. for the whole, reckoning seven dollars to the pound. Each single wire will bear a tension equal to ten cwt., and the whole twelve, consequently, 120 cwt. The weight of metal used at once is about ten cwt.

It is indispensable that the rope should be coiled within the limits of its elasticity; and, therefore, it is not advisable to have the coils of less diameter than nine feet. The cage of the whims of the shafts in the Harz are in general twelve feet in diameter. The small weight of these ropes, with wheels of twenty-eight to thirty feet diameter, freely admits of the use of buckets from nine to ten feet in height, when, in case of iron chains being employed, only four feet would be allowable with an equal power of the water-wheel. The larger diameter allows, with a slow motion of the wheel, a greater velocity, with advantage to the machine. If every bucket be made of the breadth of three or four feet, the ropes will not wrap or entangle over each other, even at the depth of 1400 feet or more, by which the injury arising from friction is avoided. The working of these ropes, in reference to the supply of water to the wheel, has proved highly satisfactory, although varying, according to circumstances. At one shaft a saving of one-fourth to one-fifth of the water was the result, as compared with hempen ropes, the work being equal. At another the saving was one-third to two-fifths. In regard to durability and economy, a positive result cannot be given, since none of the wire ropes which have hitherto been in use are yet worn out. At the Caroline shaft, which, on an average, required 3010 feet of fresh hempen rope annually (the total quantity in use being 3640 feet,) at a charge of 860 dollars, about 123*l.* sterling; there have now been wire ropes employed thirty-four weeks, which are still perfectly fit for use. So much, however, has already been saved as would suffice to make new ropes. At the present period (April, 1835,) ropes of this description are used in four of the principal shafts of the Upper Harz. In a few weeks they will be employed in two shafts more, and they will be gradually adopted, in a manner compatible with a due regard to the interest of those manufacturers who have heretofore supplied the hempen ropes and iron chains. The adoption of the wire rope is a matter of essential importance for the mines of the Upper Harz, where more than 84,000 feet of rope (partly hemp and partly iron) are in constant work, and where every year upwards of 38,500 feet of new rope are required. Mining Journal.

Description of an Air Pump of a new construction, which acts either as an Air Pump, or a Condenser, or as both; enabling the operator to exhaust, to condense, to transfer a Gas from one cavity to another, or to pass it through a Liquid. By R. HARE, M. D., &c., &c., &c,

This pump has one iron chamber,* one piston, and four valves. When in operation, it is always simultaneously exhausting and condensing; and, of course, accomplishes as much, in a given time, as two chambers of the usual construction, of the same calibre and stroke. A suction valve is placed at each end of a steel rod, which slides through the packing of the piston,† so as to be air tight, and to be pressed in opposite directions alternately. It is of such a length, that while it forces one valve, towards which the piston moves, against its seat, closing a corresponding aperture, it withdraws the other valve from its seat, and, consequently, opens the aperture with which this valve corresponds. Hence, with every reversal of the motion, the aperture previously opened will be shut, while that previously shut will be opened. Between the apertures thus alternately opened and shut, and the valve cock A, a communication is made by means of a forked leaden pipe, communicating with the valve cock at A, and with the apertures at B and C. The valve cock, by means of a gallows screw D, communicates, when desirable, with any receiver by another flexible leaden pipe P.

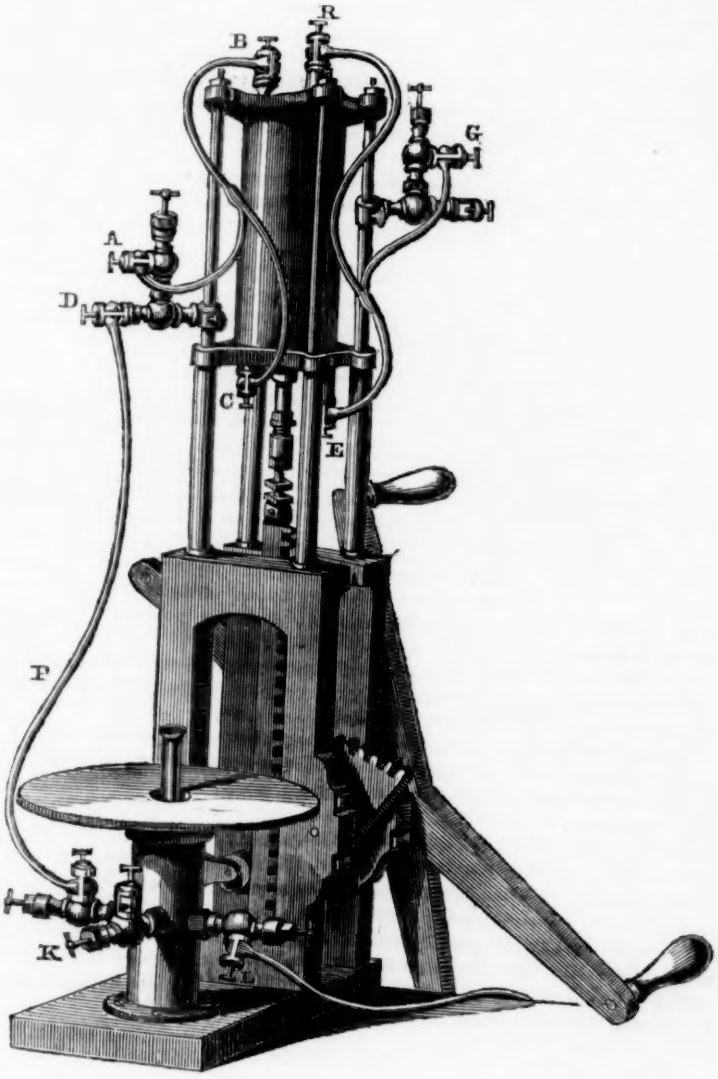
Two other analogous and corresponding apertures E R, which communicate in like manner with a valve cock G, are furnished with two valves opening outwards. These, when not subjected to any pressure from within the chamber, are kept in their places by spiral springs. They act as valves of efflux, and, like the valves in other condensers, are opened by the pressure of the air condensed by the piston as it approaches them, and are shut by springs when the piston moves in the opposite direction. It is well known, however, that this mode of opening valves, if unassisted, always allows a small portion of condensed air to remain in that portion of the chamber and of the passage leading to the valve, which the piston cannot be made to occupy entirely. This disadvantage is diminished in the case of the valves which I am describing. A stem proceeding from each valve enters the chamber so far, as that the piston cannot finish the stroke without coming in contact with the stem, and moving the valve sufficiently to allow the air to escape, without suffering any resistance from the valve and its spring.

The means by which the apertures of the suction valves communicate with a valve cock A, and may be made to communicate with the receiver through the pipe P, have been explained. By like means the communication, existing between the apertures of the valves of efflux and a valve cock G, may be extended from this valve cock to any receiver. In fact, it is only necessary to vary the situation or number of the pipes, by which communications with the chamber are effected, in order to cause the apparatus to perform the part of an air pump, a condenser, or both. When employed

* The diameter of the chamber in the instrument represented in the figure is three inches; the length is ten and a half inches, allowing a stroke of about eight inches, taking off the thickness of the piston. In order to render this instrument insusceptible of injury from mercury, it was constructed altogether of iron or cast steel.

† This contrivance was suggested to me by an excellent pump with glass chambers, obtained many years ago from Pixii. In that pump a steel rod is made to open and shut one valve: in mine the same rod opens and shuts two valves.

to transfer air, it would be more correctly designated as a forcing air pump, than as a condenser.



The disk of brass in front of the pump, serves as an air pump plate, when connected with the pump by means of the pipe P, as represented in the

drawing. It is supported on a hollow brass cylinder, furnished with valve cocks as at K L, in order to allow various experiments to be performed by means of the tube in the axis, surmounted by a cup of copper. The tube being open at the lower end, the cup is accessible to an incandescent iron. This contrivance facilitates the exposure of substances to heat, either in vacuo, or in any gas. When boric acid and potassium are thus heated, boron is evolved. By means of a similar arrangement, heating chloride of calcium with potassium, I obtained a potassuret of calcium, which decomposed water and yielded a solution which was rendered milky by carbonic acid.

When a glass globe of fifteen gallons is exhausted over this plate, and filled with oxygen gas, phosphorus having been previously placed in the copper cup, on heating the phosphorus, a combustion ensues of transcendent splendour.

For this and other experiments, the hollow cylinder, which supports the air pump plate, may be screwed into a hole in a table and placed at any convenient distance from the air pump. With this view, there is a conical screw cut upon the lower end of the cylinder.

The mechanism by which the piston is moved, is too obvious to need description. There is, however, a peculiarity in the construction of the piston rod, which is of great utility. The rod is hollow, having been sufficiently reduced in diameter from a piece of gun barrel by the wire drawing process. The bore of this *hollow* rod is occupied by a solid rod, which extends from the metallic disk, at the farther end of the piston, to the rack. To the other disk, the hollow rod is fastened. The leather packing between the disks, being turned in the lathe so as to fit the calibre of the chamber accurately, is made more or less tight by the action of a screw just above the rack. Hence the pressure may be regulated without taking the pump apart, which is always troublesome, and at some periods impracticable within the time at command.

With respect to the efficacy of this pump, satisfactory proof was given some time since, at the Franklin Institute, when it raised the mercury very near to the height of that in the Torricellian tube.

Having been in possession for many years of an elegant air pump with glass chambers furnished by Pixii, we have been induced to give the preference to the new instrument, in all cases where a perfect exhaustion has been desirable.

Of the three valve cocks, one usually communicates with a gage; since, instead of an instrument of that nature permanently associated with the pump, and which is subjected to exhaustion by means of a lateral communication with the perforation leading to the cavity of the receiver, I employ a moveable barometer gage, which is made to communicate with the receiver directly. The operator is thus enabled to observe the quantity of gas in the receiver, after the communication with the air pump is arrested by closing the valve cock through which it was established.

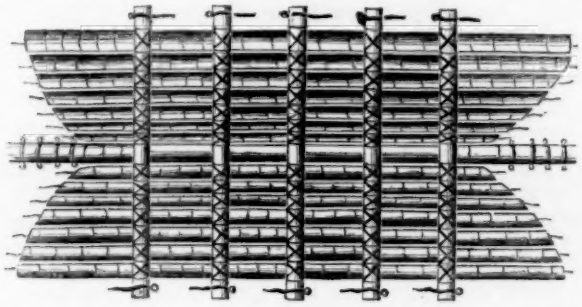
Trans. Amer. Phil. Soc.

India-Rubber Life boat. By Lieut. Robert Wall, R. N.

Sir,—Having observed some notice of boats having been constructed of India-rubber, in some of the recent numbers of theMechanics' Magazine, I

beg leave to forward to you a drawing and description of a life-boat partly formed of that material; which plan I communicated nearly two years since to a gentleman, whose testimony I can refer to if necessary.

It is proposed to construct the framing of the boat of tubes of India-rubber (of any required length and diameter,) each secured by a cover of patent water-proof canvass. Having provided a sufficient number of these, in proceeding to put them together, they are to be laid flat on the ground, the longer ones outside; across which, at certain intervals, are to be laid shorter tubes of somewhat greater diameter, to which they are to be firmly lashed by thongs or other means. To each end of the transverse tubes, are to be attached thimbles and lanyards; and underneath all, fore and aft, is to be a tube longer than those at the side, fitted at each end with the necessary number of thimbles and lanyards for attaching the ends of the side-tubes. All things being thus prepared (see figure,) the cross-tubes are to be bent



upwards by receiving the lanyards through their opposite thimbles, and drawing them together will give the bottom of the boat a rounded form. The ends of the fore and aft tubes are then to be attached to the ends of the long centre-tube, when, by drawing all parts closely together, the ends of the vessel will be secured, and the stem and stern formed like those of a whale-boat. In order to prevent the sides of the boat from being pressed inwards, as well as to form seats for the rowers, a series of circles, formed of the same materials, are to be placed between the cross-tubes, and lashed firmly to them and to each other. The whole is then to be enclosed within two covers of patent canvas; the one outside to be finer than the other, and paid over with liquid India-rubber, to facilitate its passage through the water. Outside of all, about six inches below the gunwale, is to be placed on each side a tube of the same material, double the diameter of the others, in the centre, but tapered off to nothing at the ends, and covered with leather, which would serve as a fender on going alongside of ships in distress, and, together with bags of water for ballast, would effectually prevent the boat from being capsized. To obviate the chance of any of the tubes being wounded, and so permitting the escape of air, it is proposed to have transverse partitions of India-rubber placed in each of them at short intervals.

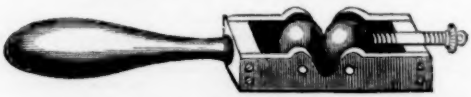
Although the system is now proposed for the construction of a life-boat only, I see no reason why it might not be adopted to almost any extent for the purposes of general navigation; nor can I at this moment say what limit could be assigned to a vessel's size, constructed of such materials. This principle might also be substituted with great benefit for the copper-tubes,

which have been suggested, for giving increased buoyancy to vessels, by placing them between the timbers and beams. Such tubes as the above, in addition to their superior buoyancy and cheapness, might, in the event of distress or shipwreck, form a secure raft, or even a vessel, in which the crew and even some portion of the cargo might be saved.

In conclusion, Mr. Editor, I would strongly recommend that a small life-boat, constructed on these principles, be carried on board of every sea-going vessel, which would be of the utmost use in many situations of danger. Why not a life-boat as well as a life-buoy?

P. S.—The tubes in the drawing are placed somewhat apart to render it more distinct; but in a model they would be close together. The upright ends of the tubes are intended for tholes for the oars. Lond. Mech. Mag.

Expeditious Razor Sharpener.



By fixing in a frame two smooth steel balls, in contact, the finest possible edge may be given to a razor, by drawing it between them. The balls are of cast-steel, three-fourths of an inch in diameter, with a hole drilled through the centre of each. The screw at one end, was added for the purpose of keeping the balls in contact. This screw, also, affords the additional advantage, that if the pivots are suffered to be a little loose in the frame, the balls may be turned and again fixed. The balls are made as hard as possible, and polished in a direction opposite to that of their axes; whether a perfectly spherical or an oval figure would be the best, is not ascertained. The handle is made of ivory, and the frame of brass.

Upon a short trial, by myself and others, this instrument promises to give an exceedingly fine edge to every description of cutlery for which such an edge may be required. The mode of using it is to draw the edge of the razor a few times, perpendicularly, with a very light or moderate pressure, between the balls. It is, however, essential, that a mixture of putty-powder and oil, about the consistence of very thick cream, or putty-powder and mercurial ointment, or some equivalent substance, should be placed between the balls, forming a sort of bed, through which the edge of the instrument is drawn; it should afterwards be strapped on the hand. This process may be resorted to as often as the edge of the razor becomes dull—once, twice, or three times a week—and I have found that an exquisitely fine edge may be thus produced in a few seconds. Of course, no instrument would be suited to this mode of sharpening unless it had previously a thin edge.

This instrument, though a modification only of the table-knife sharpener now in use, has a different action, produces a different edge, and is, therefore, applicable to a different purpose. It is superior to Mr. Knight's razor-sharpener in this respect, that both sides of the edge being acted on equally, and at once, the edge may be compressed; it is, also, kept in the centre, and is liable to be neither bent nor broken. But it seems to combine the principles and advantages both of the table-knife sharpener now in use, and of Mr. Knight's steel. Ibid.

On a New Pigment. By W. Brockedon, Esq.

For many years I have been in the practice of using as a pigment, the black oxide of manganese: it possesses some most advantageous qualities, particularly those of great body, and an extraordinary readiness to dry. I mentioned this to you some time ago, and stated the difficulty which existed in introducing it among painters, either in the fine arts, or for common purposes for house and out-door painting.

I have, however, steadily persevered in its use, and if I can point out its advantages to others, it may not form an unworthy notice for the Society's volume.

I originally obtained it from the mammillated ore; subsequently I procured it from Knight's, in Foster Lane. In this state it is not a substitute for any colour previously known: it is a very dark iron-gray. A very small quantity will stain a large volume of white; and alone, even when very thin, it will completely obscure even light objects beneath it. But its most valuable quality to me is its very rapid tendency to dry, even when ground in cold-drawn linseed oil. A few hours only are necessary for its hardening.

Within these two or three years, however, a new variety of this colour has been introduced from Ireland, being found at Cappah, near Cork, on the estates of Lord Audley, which are now worked by the West Cork Mining Company: this colour is composed of peat (the material of Vandyke brown) and manganese; the presence of the former greatly enriches the colour. In water-colour it is more intense and beautiful than Vandyke brown, and differs from this in having a greenish brown cast of great richness; and, for facility of working on paper, is unmatched; but in oil it is still more valuable, because is has the brilliancy and depth of asphaltum, with the quality of drying in a few hours, an advantage of great importance to an artist who is painting a deep-toned picture, but who is pressed for time. Both in oil and in water these colours are so essential to me, that I would now rather discard any other single colour that I am acquainted with.

But it is not merely for these finer purposes that the Cappah brown is particularly useful: the West Cork Company have introduced it in large quantities. The consumption of it for art is a mere trifle; for shipping and house painting, however, no colour equal to it has yet been found, in depth, richness, durability, and cheapness.

In some cases attempts have been made, by washing it over, to obtain from it two or three different colours, which have been brought into market under the name of euchrome. To these, the remarks in this letter do not apply, but to the entire substance, without any preparation except that of grinding. This it is which I have tried in various ways and have found to be most valuable; and am fully persuaded, that if offered to the public in this state, as a cheap, rich, and durable colour, the proprietors would at the same time remunerate themselves and render an important service to house and ship painting.

Trans. Soc. of Arts.

Miner's Mirror.

The Silver Medal was voted to Mr. Joseph Gretton, of Timberfield, near Chesterfield, for his Mirror; a model of which has been placed in the Society's Repository.

Mr. Gretton states, that, having occasion to make a drift in a colliery, he

was obliged to have the iron tram-road taken up in order to avoid the local attraction which otherwise would have been exerted on the needle of the compass employed in that operation. This inconvenience induced him to try if he could not find some other guide in forming a straight drift, either level or inclined; and the result was the invention of the instrument sent by him to the Society.

The miner's mirror consists of a cast-iron circular plate, $5\frac{1}{4}$ inches diameter, and $\frac{1}{4}$ of an inch thick; on one side of which, and in the middle of the plate, is a semi-globular projection, the diameter of which is $1\frac{1}{2}$ inches. On the other side of the plate, and concentric with it, rises a projection which is one inch from the edge of the plate, in the form of a hoop, 1 inch high, $\frac{1}{4}$ of an inch thick at the base, and little more than $\frac{1}{16}$ of an inch thick at the edge: (this leaves the sides of the hoop sufficiently sloping to allow of its being taken out of the sand with facility when moulded at the iron-founders.) In the inside of this hoop, which is 3 inches in diameter, a mirror is fixed by placing a small quantity of glaziers' putty all round the hoop, in the angle at the bottom, and pressing down the mirror firmly upon it. The mirror is then to be attached to one end of a piece of board, about 14 inches long, 5 inches broad, and $1\frac{1}{2}$ inches thick, by means of four screws passing through four holes drilled through the plate, within half an inch of its edge, and at equal distances from each other. The semi-globular projection at the back of the plate keeping it at a small distance from the board, allows of the adjustment of the mirror by means of the screws. A tin cover may be fitted on the hoop for the protection of the mirror, but the projection of the hoop only will generally be found a sufficient protection against accidents. This instrument may be manufactured for about 1*s.* 6*d.*

This mirror is intended to guide the workman when he is driving levels, headings, or drifts, in coal seams, or levels or drifts in any other strata, when the drifts are required to be driven in a straight line, and in a particular direction, as horizontal or inclining, and at the same time towards a particular point of the compass.

Suppose it to be required to drive a heading in the canal from one coal-pit to another at a considerable distance; first, let five or six yards be driven in the required direction, as near as may be without the mirror. Then place a dial (miner's compass) at the extremity driven, with its sights in the direction of the two pits (before ascertained on the surface of the ground;) then insert the board of the mirror into the solid coal on the side of the drift, near the bottom of the pit; and wedge it fast, in such a situation as that the mirror may be in the line of the sights of the dial. Then adjust the mirror, by means of the screws, so as to reflect the light of a candle in the line of the sights of the dial. Then the driving of the heading may be proceeded with, and the workman may at any time know if he has proceeded in the right direction by merely holding the candle by which he works between his eye and the mirror, and if he can see its reflected image in the mirror, of course he has proceeded right; if not, he must know he has proceeded wrong. When the workman gets a considerable distance from the mirror, say 50 or 60 yards, it should be removed nearer to him and fixed as before, as the image of the candle is not so distinctly observed at that distance. In this manner drifts may be driven to any length in the required direction, by ordinary workmen.

The mirror may be made to reflect the image of the candle accurately horizontally, by adjusting the mirror to reflect the image of the candle so

as to correspond with the sight of a spirit level: thus it may be useful in driving dry levels under ground; for, in this case, the reflected image of the candle should always be at the same height above the floor of the level as the mirror is.

The mirror may also be adjusted so as to reflect the image of the candle to any angle of elevation required, by making it reflect the light so as to correspond with the sight of a spirit level having a graduated arc, and fixed to the proper degree of elevation: thus the mirror may be useful in the driving of inclining drifts.

The miner's mirror recommends itself on account of its simplicity, and the ease and accuracy with which the miner may, at any moment, examine his work. Ibid.

Mr. Coad's Plan for Consuming Smoke.

Mr. Richard Coad of this town has taken out a patent (sealed July 10, 1835) for an invention of his for getting rid of the nuisances from steamboats and factories, by making the chimneys consume their own smoke. To borrow a passage from a contemporary to explain this,—"The smoke is a certain quantity of the inflammable matter of the coals, which is lost by evaporation, instead of being burnt." Now, Mr. Coad's method consists in supplying this smoke with the quantity of heat that is necessary for its perfect combustion; and this is effected in a very simple and ingenious manner. An apparatus consisting of a series of small tubes, or chambers, so constructed as to expose a large surface to the action of the heat, is placed in the lower part of the chimney beyond the boiler: one end of the series communicates, by an open orifice, with the external air, while the other opens into a slit in the bridge of the surface. This is the whole contrivance, and it acts thus:—The superfluous heat in the chimney raises the temperature of the iron tubes to a high degree, and the draught in the chimney causes a current of air into the fire through every aperture, and, consequently, through the heated tubes: a current of hot air is thus thrown into the flame at every point where the smoke begins to be formed; and the effect is, that the deposition is prevented, and the flame and heat of the fire are both much increased, and not a particle of the smoke escapes from the top of the stack. It will be seen from the foregoing statement, that the means by which Mr. Coad accomplishes this object are as simple as they have hitherto been found effective; and the saving in fuel, from the peculiar operation of the invention, we are assured by several persons of experience, will be immense. The principal merit of Mr. Coad's patent consists in bringing back the caloric, which in almost every instance is entirely lost to the manufacturer. We trust, for the sake of the health of the town, that no feeling of dislike to new inventions will prevent the use of this apparatus from becoming universal.—(*Liverpool Telegraph, Dec.* 14, 1836.) Architect. Mag.

On the best mode of Warming Buildings.

The first requisite is a complete combustion of the fuel; and the second, a complete delivery of the heat evolved in the place intended to be warmed. Nothing could be more wasteful of fuel than common open fireplaces: only one part in fifty radiates into the room, the great body of heat going up with the draft of the chimney. If a kettle of water be placed before the fire it will not boil in less than twenty-four hours: placed over the fire, it

boils in half an hour. If a man stand in front of the fire, he gets only half warmed; the half next the fire is warmed, while the half away from it is chilled: but, if he were to place himself in the line of the draft over the fire, he would soon be burnt to a cinder all around. The ancient Romans understood these things better than the moderns: they carried their flues horizontally under the pavement of the chamber to be heated. A stove on the same principle was erected at the County Fire Office ten years ago, which has answered perfectly; and Mr. Beaumont has erected similar stoves at the elephant-house in the Regent's Park, at Sudbury Grove, at St. James's Church, and other places, with similar success. These simple contrivances produce a saving of eleven twelfths of the fuel consumed to obtain the same warmth by hot-air and hot-water stoves, and with perfect freedom from dirt, dust, smoke, and impurity of every kind. He was sure they only required to be more known to be adopted in all the churches and chapels throughout England." Ibid.

Mosaic Gold.

The British manufacturers melt together, at a heat just necessary to keep copper in fusion:—

Copper, - -	100 parts.
Zinc, - - -	52 to 55

The copper is first melted and the zinc in small portions is gradually stirred in until the melted mass has the colour of fine gold.

If the heat be too high, a portion of the zinc is volatilized and nothing but spelter is obtained. At a proper temperature the colour gradually changes, by the addition of the zinc, from purple or violet to a pure white, when the alloy has attained to its perfect condition.

It is then poured into ingots or moulds, as required.

It is difficult to remelt this compound without injuring it, as a portion of the zinc, at the necessary heat, is apt to fly off. Jour. des Connais. Us.

Ivory or Animal Black, used in Refining, Clarifying, Painting, and in Cements.

The following process is recommended by M. Payen:

Take 90 kilogrammes of bones from which the gelatine has been extracted and ten kilogrammes of tar obtained by the distillation of coal in the preparation of gas. Mix these well together and leave them in a heap one or more days, then put them into a close, or warm, vessel so that the decomposition may be completed.

During the operation a large part of the carbon of the tar is insinuated into the interstices of the bones, and produces an intensely black compound which possesses all the qualities desirable in discoloration, painting, waxing, &c.

Many other tars, fixed or volatile oils, various fatty or resinous substances and other bituminous matter of the vegetable and animal kingdoms in which the carbon is in a state of minute division, are also adapted to this operation. Ibid.

Cement for Cisterns, &c.

Common rosin 30 pounds, melt it and take off the scum, then add very fine yellow sand 45 pounds, Spanish brown 2 pounds, mix the whole thoroughly with an iron shovel or other instrument. Ibid.

To prevent Common Ink from attacking metallic Pens.

This destructive agency is owing to the sulphuric acid contained in the sulphate of iron (copperas) used in ink making; to gallic acid, an almost constant ingredient, and often to acid from the decomposition of sulphate of copper, which is injudiciously added to ink.

After trying alkalies, (which render the ink thick) the method I prefer, is the most easy and simple as well as indicated by theory, and which is completely sanctioned by practice, is to decompose or neutralize all these acids by an excess of iron. It is quite sufficient to throw into the ink bottle a few small nails, the remains of metallic pens not varnished, or any pieces of iron without rust. If the pens are still acted upon, it is only an indication that more iron must be added. Eleanor Celuart. Ibid.

Light for Steam-vessels.

The Silver Medal was voted to Mr. G. H. Pearce, of Brunswick Terrace, Blackwall, for his distinguishing Light for Steamers; one of which has been placed in the Society's Repository.

The common light which steam-vessels carry, is a globular lantern at the mast head. To this there are the following objections: 1st. There is nothing in this to distinguish it from the light ashore; and, as the voyages performed by most steamers are coasting ones, this ambiguity may lead other ships into dangerous errors. 2dly. It does not enable the seaman to distinguish a steamer from another vessel, which, considering the rapid rate of going of a steamer compared with a sailing vessel, may often be productive of danger to both vessels.

The lantern proposed by Mr. Pearce is a quadrangular one of sheet copper, the lamp having four burners, and being backed by a reflector. The front piece is a plate of white or colourless glass; the right hand or starboard one is red; and the left hand or larboard one is green. The cost of the lantern complete is about 5*l*.

Mr. Pearce states, that in consequence of the obvious superiority of his lantern over that in common use, as shewing, by mere inspection, not only that the vessel which carries it is a steamer, but, as indicating the relative position of the vessel, and also the direction in which she is going, it has been adopted by about twenty steamers, and has given general satisfaction.

The perfect originality of indicating, by different coloured lights, the relative position of two ships, may perhaps be questioned; but as, in all matters of this kind, the use of an invention depends on its general adoption, the Society, in voting their reward to Mr. Pearce, considered the successful efforts that he has made to introduce his lantern into use, and that their reward and approbation may stimulate him to make further exertions for its general adoption by the steamers of the united kingdom. Trans. Soc. of Arts.

Sugar of Milk.

The sweet taste of new milk is owing to the sugar which it contains; a substance which, having found some medical reputation on the Continent, is prepared in considerable quantity in some parts of Switzerland. The whey produced in making cheese is first heated, to separate the butter from it, and is then boiled down to the consistence of sirop: it is then poured

into earthen pots, and exposed to the sun till it becomes nearly solid. The mass is then put into water, and heated till the sugar is dissolved; and the hot liquor being poured through a linen filter, the insoluble impurities are for the most part separated: it is then clarified with white of egg, is again evaporated, and deposits, on cooling, a whitish chrystalline mass, which is the sugar of mik. Although in its chemical analysis this substance differs but little from vegetable sugar, yet it is much less soluble in water; and the solution, though mixed with yeast, and placed in circumstances favourable for the vinous fermentation, will not undergo this change. Even entire milk ferments with great difficulty, although there can be no doubt of its being capable, by proper management, of passing into this state; because the Tartars are in the constant habit of preparing a fermented liquor from mare's milk: it is called by them *kumis*, and affords alcohol by distillation. Ibid.

Progress of Physical Science.

*Remarks on the supposed connexion of the Gulf Stream with opposite currents, on the coast of the United States.** By William C. Redfield, Corresponding Member of the U. S. Naval Lyceum.

It appears from numerous observations which are recorded in the American Coast Pilot, that immediately contiguous to the borders of the Gulf Stream on the North American coast, a moderate current is generally found setting to the southward and westward, or in the direction which is opposite to the stream, and parallel to the general line of coast. By a natural and familiar association, this current is generally styled *an eddy current:* but we shall probably find, on more particular inquiry, that it has little or no claim to this character. An eddy, as is well known, is usually caused by some fixed obstacle opposed to a stream, and is strictly local, and nearly circular in its action. Moreover, it derives its waters directly from the parent stream, and necessarily partakes of the same temperature. I must, therefore, dissent from the views of those persons who refer this current to the eddying action of the Gulf Stream for the following reasons:—

1. Because this current, in open sea, no where assumes the *form* of an eddy, but, when unobstructed by violent winds, maintains its course towards the southwest, on a line which is parallel to the general direction of the coast.

2. Because, on the outward edge of the Gulf Stream at least, there are no obstacles presented which could divert the progress of that portion of the stream, and circumscribe the same in eddies.

3. Because, if this current was derived from the Gulf Stream, it must necessarily partake of its temperature; but the sudden reduction of temperature on leaving the margin of the stream is most remarkable, and is almost unparalleled except in the immediate vicinity of ice.

We shall in vain attempt to explain this extraordinary change of temperature by the proximity of shallows or soundings, for this cannot avail if the water itself be derived from the gulf current, to say nothing here of the general unsoundness of this explanation.

I have long since become satisfied that the current in question is neither more nor less than a direct continuation of the polar or Labrador current,

* Republished from the Naval Magazine for the present month, at the request of the author.

which bears to the southward the great stream of drift ice from Davis' strait, and which, in its progress to the lower latitudes, is kept in constant proximity to the American coast by the dynamical law or influence which, in the northern hemisphere, causes all currents which pass in a southerly direction to incline towards the west, in consequence of the increasing rotative velocity of the earth's crust in the opposite direction, as in the case of the trade-winds in the lower latitudes.

In collating the observations of various navigators which have been published, we find reason to conclude that, in ordinary states of weather, this current may be traced from the coast of Newfoundland to Cape Hatteras, and perhaps to Florida, the reflux influence which follows a violent gale being of short duration.

According to this view of the case, the Gulf Stream, in its course from Florida to the Bank of Newfoundland, is for the most part imbedded or stratified upon a current which is setting in the opposite direction in its progress from the polar regions. The impulses by which these diverse currents are maintained being, however, as permanent and unchanging as the diurnal rotation of our planet, their opposite courses on this coast while in contact with each other, are no more surprising or inexplicable than the case of two opposite currents of atmosphere, and the latter are often known to maintain opposite courses for a long period, and at high velocities, while thus superimposed one upon the other.

From the fact that these great currents have their origin, one in the tropical and the other in the polar seas, their presence can be unfailingly identified by means of the thermometer; and with the aid of good chronometers their position and extent may be determined with greater certainty than has yet been done, particularly in the latitudes between Nantucket and Florida. In this department of hydrology, every navigator may contribute something of value to his profession and to science, for which no other qualifications are required than frequent observations, and proper attention to the ship's place. It is desirable, therefore, that every ship-master who traverses this region should make and record his observations hourly upon these currents.

The drift ice from the polar basin is always found in the western portion of the North Atlantic Ocean, notwithstanding the influence of violent westerly winds. A writer in the London Nautical Magazine* supposes that a portion of the polar current which bears the ice along the eastern edge of the Grand Bank into the Atlantic, there becomes exhausted, or joins the Florida stream. And in the Encyclopedia of Geography,† it is stated that the waters in the Northern Ocean, in the space comprised between Greenland and the coasts of Britain and Norway, and between Labrador and Spitzbergen, are supposed to perform a perpetual circuit; and that, being returned to Newfoundland, they recommence their revolution.

It is doubtless true that the great stream of ice is brought by the Labrador current within the dissolving influence of the Gulf Stream; and I may here remark that it is not improbable that the Grand Bank owes its origin to the deposites which have resulted from this process during a long course of ages. But the polar current probably "joins" the Florida stream in no other manner than by passing underneath the same, or yielding it a passage

* Nautical Magazine for March, 1837, p. 139. In this article it is stated that between 42° and 43° west, is the farthest easterly position in which floating masses of ice have usually been found.

† Phil. Edition I, p. 196.

upon its bosom, the order of superposition being mainly determined by the great diversity of temperature. The icebergs being thus carried southward by the deeper polar current, even after the latter has lost its influence at the surface, their dissolution is speedily effected by the tepid water of the Gulf Stream, and we are thus relieved from these dangerous obstructions, which would otherwise be found in lower latitudes of the Atlantic. These two streams or currents, therefore, neither meet nor coalesce in any proper sense; but like other currents, both atmospheric and aqueous, pursue each its determinate course, the Gulf Stream being thrown eastward by the greater rotative velocity which it acquires in latitudes nearer the equator; and the polar current being thrown westward along the shoals and soundings of the American continent and its contiguous ocean depths, by the more tardy rotation which it derived in higher latitudes.

The writer in the Nautical Magazine above alluded to, supposes the natural course of the polar current from Davis' Strait to be towards the coast of Morocco, in North Africa; but a little attention to the effect of the earth's rotation on this current, will show that both it and the ice-drifts which are borne on its surface, must tend westwardly as above described, in despite of the powerful westerly gales which prevail in these latitudes. Light articles, however, such as bottles which are set afloat to determine the drift of currents, will not only yield greatly to the influence of these winds, but on falling into the surface current of the Gulf Stream will of course accompany this current in its progress towards the coasts of Europe, where a leading branch of this stream is found sweeping along the coast of Norway towards the recesses of the Polar Sea, and which appears to be ultimately resolved into the Labrador current. The southeasterly branch of the stream, on leaving the Grand Bank, assumes the shorter and more direct circuit of gravitation by the coast of North Africa to the tropical latitudes, from whence it again merges in the Florida stream. It is by this system of compensation, aided by various subordinate gyrations, such for instance as Rennell's current, that the great mechanical system of oceanic circulation is apparently maintained, and which may be supposed to have a powerful influence upon the climate of Western Europe. Were the influence of winds wholly unfelt upon the ocean, it is probable that the same system would continue to be maintained, in all its essential features, by the mechanical influences of the earth's rotation, combined with an unstable state of equilibrium. The energy of this rotative influence, by which the earth is flattened about twenty-seven miles in its polar diameter, and the depressive force of which, in each polar basin, is equal to that of a column of mercury more than five thousand feet in height, is at least sufficient to maintain the existing movements and mechanical relations of the terrestrial fluids, under the various and continued oscillations to which these fluids are necessarily subjected.

One fact, too important to be omitted here, will serve to demonstrate the course and identity of the great ice-current for more than half the distance from Cape Race in Newfoundland to the coast of Massachusetts. On the 7th of July, 1836, H. M. packet Express passed between two large ice islands to the southward of Nova Scotia, in lat 43° 13′ N. lon. 61° 17′ W., temperature of the water 42 degrees, depth 45 fathoms; the most western of these icebergs being in lat. 43° 09′, lon. 61° 26′, or about 75 miles southwesterly from Sable Island.

From the temperature of the sea upon the North American banks and soundings, and in some other positions which are deemed analogous, it has

been assumed that the mean temperature of the sea is lower on shoals than in deep water, but it seems difficult to account for such a result, unless upon the ground already mentioned. It has, indeed, been ascribed to radiation from the bottom; and again, it has been denied that radiation from a non-luminous body can be carried on freely through the water, and as the colder particles have no tendency to rise towards the surface, it does not appear how the supposed reduction in the temperature of the bottom can materially affect a current of fifty or twenty fathoms in depth, which is derived from a foreign source; for on none of these shoals or soundings, is the water permanently quiescent. Were it otherwise, we might reasonably expect a diminution of temperature on shoals in winter, and an increase in summer, with a permanent increase if in tropical latitudes. I am informed by George W. Blunt, Esq., who has made a course of regular thermometrical observations while crossing the Atlantic, that on entering upon soundings in the English Channel, he has found an increase of temperature in the water of 2° Fahrenheit. Those who differ from our views in regard to these currents, ought, therefore, to propose some hypothesis which will account for the extraordinary low temperature of the waters which leave the Atlantic coast of the United States. Were these waters derived as an eddy current from the Gulf Stream, it is probable that they would no longer serve for the myriads of codfish which now frequent our shores, and which appear to inhabit the coldest waters.

Many experiments upon the drift of currents have been made with bottles containing memorandums of the date and locality in which they were committed to the sea. These experiments are not without their value, although it is obvious that a circuitous course is liable to be construed into a direct one, and that violent winds may greatly affect the course of such objects upon the surface of the ocean, while an important diversion may also result from a superficial cross current, as we have noticed in the case of the Gulf Stream. Perhaps the suspension of some suitable weight to these floating messengers, with a line from five to twenty fathoms in length, would afford results of a more satisfactory character; although the duration of such pendulous fixtures can hardly be relied on. If fitted in this manner, the fact should be noted upon the memorandum inclosed, which should specify also the length of line which may be attached.

A full knowledge of the general system of currents in every ocean is obviously of great value to the nautical profession, and is important, also in its relations to physical science. It is hoped, therefore, that these considerations will prove sufficient to stimulate our navigators to make and record the necessary observations, and to promulgate the same through the proper channels of information.

Meteorological Retrospect for the year 1836. By W. H. White, Esq.

From the increasing importance which a more accurate attention to atmospheric phenomena is assuming at the present time, under improved modes of observation, and over more extended regions of land and sea,—the following "Retrospect for the year 1836" in England, by W. H. White, Esq., appears to be not unworthy of a place in an American Journal, as a means of comparison, with the past year, in the United States. G.

This *year* commenced with a very sharp frost. The minimum temperature of the night of the 1st was 12° of Fahrenheit, which was also the

minimum for the whole year. Thaw commenced on the 4th; and on the 5th, at noon, the thermometer stood, in the shade, at 50°. Frost returned on the 8th; a slight fall of snow took place on the 11th. The remainder of the month was dry and mild.

At 6½ A. M. on the 13th, a very beautiful meteor appeared in the E., and took a S. W. direction. It was visible about 3 seconds with a short train of sparks.

February was, upon the whole, a rough tempestuous month; N. and N. W. winds prevailing, particularly on the 17th and 18th, which were two very stormy days. The latter part of the month was cold and wet; nights slightly frosty.

March exhibited an unusual range of the barometer; and more than an average quantity of rain fell. There were only four fine days. Prevailing winds, W. and S. W., with a few frosty nights towards the close of the month.

April was the coldest corresponding month known in England for many years, especially at the close, which was characterised by severe frosts and snow, and strong northerly winds. On the last day of the month, the thermometer was 29° at 8 A. M.; which cold was very injurious to fruit trees and tender vegetation.

May was particularly noted for a continued series, for twenty-eight days, of dry cold N. and N. E. winds: the only interruption was a S. W. wind on the 11th, 12th, and 13th. Grass became parched with drought, and vegetation was scanty and unhealty.

June was also a dry month, and not hot, with prevailing S. W. winds. Vegetation recovered its healthy appearance, but remained very scanty.

July commenced with great heat, especially during the first ten days. Thunder on the 5th and 6th. The 20 and 21st were remarkable for being tempestuous, with strong gales, accompanied with thunder, lightning, and heavy rain, which greatly reduced the temperature. On the 20th, so great was the change, that the thermometer, which at noon stood at 75°, at 3 P. M. was only 50°. One of the most perfect solar halos I ever witnessed, exhibiting the prismatic colours in high perfection, with a parhelion below the sun, appeared at 8 A. M., and continued visible till 11 A. M. The barometer was sinking at the time the halo appeared, and rain followed in twenty hours.

August was decidedly the finest month in the year, notwithstanding the great prevalence of N. E. winds. A violent thunder storm passed over on the 14th, accompanied with heavy rain. This storm was very violent, between 8 and 9 P. M., at Liverpool, and did much damage to the shipping in the harbour. A violent thunder storm, on the same day, did much damage in Austria, destroying houses, barns, and even life.

September. The cold northerly winds, and constantly cloudy sky, for the first twenty days of this month, reduced the temperature of the month much *below* the mean.

October was wet, cold, and stormy, especially the 1st, 6th, 11th, and 12th. Auroræ boreales were visible on the 5th, 15th, and 18th. On the 29th snow fell to the depth of 4½ inches in the metropolis. In the country it was considerably deeper, and did not entirely disappear till the 1st of

November, the first week of which was wet and cold, with frosty nights. From the 8th there was an almost uninterrupted succession of S. W. winds, accompanied with light showers, till the memorable hurricane on the 29th, which was one of the most terrible known in England for many years. The

violent gusts of wind, chiefly from the N. W., did much damage, leaving many a sad memento behind both by land and sea. From the most authentic accounts of this gale which have reached me, it appears that it commenced on the 23d, on the eastern shores of North America, off St. Lawrence. A ship from Poole fell in with it on the 26th, in lat. 47° N., long. 32° 20′ W., and was thrown on her beam ends. It continued its progress across the Atlantic, and reached the Land's End about $7\frac{3}{4}$ A. M.; Plymouth, $8\frac{1}{2}$ A. M.; Exeter, $9\frac{1}{2}$ A. M.; Weymouth, 10 A. M.; Poole, $10\frac{1}{2}$ A. M.; Farnham, 12 noon; London, $1\frac{1}{2}$ P. M; Suffolk coast $2\frac{1}{2}$ P. M.; and Hamburg, at 6 P. M. Thus the storm traveled at the rate of about 50 miles per hour; but the circular motion of the wind had a velocity of from 120 to 150 miles per hour. The fury of the gale was most felt on the coasts of France and Belgium. At Ostend there was scarcely a house which was not unroofed; and so great was the demand for tiles, that they rose from 16 to 30 florins per 1000. The motion of the mercury in the barometer, during the most violent part of the hurricane, attracted great attention. On the morning of the 29th, at 9, the mercury stood at 29.30 inch.: it soon afterwards began to sink very rapidly, exhibiting much agitation during the violent gusts of wind, for which this hurricane was particularly remarkable, till 12 at noon, when it stood at 28.82 in. At 2 P. M. the barometer had risen to 29.35, soon after which the wind lulled into almost a calm.

December came in with an unusually high temperature. The thermometer ranging between 50° and 56°. The min. during the nights of the 4th, 5th, and 6th, was above 50°. The great prevalence of S. W. winds during the first three weeks may account for the very high temperature; and, indeed, the very high winter temperature during the last three years may be attributed to the same cause. On the 23d,* the wind shifted suddenly to the N., with a sinking barometer, and decreasing temperature, which was introductory to the memorable snow storm on Christmas day, which will be long remembered by the Londoners. Communication with the metropolis, for one whole week, was greatly retarded by land, the effects of which were seriously felt by the commercial houses. The drifted snow, in many places, measured from 12 feet to 16 feet in depth, but the average depth, as nearly as could be calculated was about 4 feet. In London, the principal streets, during the whole of the Christmas week, resembled ploughed lands. The snow, having become mingled with the dirt in the streets, had lost its whiteness, and had very much the appearance of black mould; so that carriages passed along the streets as silently as they would have done along a ploughed field. The gale on Christmas day from N, and N. E., independently of drifting the snow, did much damage to the shipping on the east coast. This gale, I believe, was general all over England; but the direction in which the wind blew varied at different places to almost every point of the compass. There was a considerable fall of snow in Spain, with an unusual decrease of temperature.—*London, Feb.* 13, 1837.

Loudon's Mag. Nat. History.

* At New York, Dec. 21st, at 11 A. M., the thermometer stood at 50° Fahrenheit above zero. In twenty minutes, it fell 32°; and at 9 P. M. it stood at 16°. This sudden change was succeeded by a fall of snow, which was carried away by heavy rain and a S. W. wind, on the 27th inst., to the overflowing of several rivers. On the 28th, a N. W. wind blew with a hard frost.

On an Artificial Substance resembling Shell. LEONARD HORNER, Esq. F.R.SS. L. & E.

While officially inspecting the cotton-factory of Messrs J. Finlay & Co., at Catrine, in the county of Ayr, he was struck with an unusual appearance of a part of the machinery, which at a distance, looked as if it were made of brass. On a closer examination, he found that it was a large circular wooden box coated with an incrustation of a brown compact substance, having a highly polished surface, a metallic lustre, in some places beautifully iridescent, and when broken exhibiting a foliated texture.* This resemblance in structure and pearly lustre to some species of shells, such as the *Leleagrina*, *Malleus*, *Avicula*, *Ostrea*, *Pinna*, and others, induced me to examine the substance more closely, conceiving that it might possibly throw some light on the formation of shell.

The part of the machinery on which he observed the incrustation is called a Dashwheel, and consists of a circular box, about seven feet in diameter and three feet in width, revolving upon a horizontal axis, and having its interior divided into four compartments, into each of which there is a circular opening on one side. The purpose of this wheel is to wash or rinse the cloth in pure water, after it has been boiled or steeped in the bleaching-liquors. It makes twenty-two revolutions in a minute, which is found to be the proper degree of speed, in order that the cloth may be tossed about and *dashed* against the sides as the wheel turns; a greater velocity causing it to keep at the circumference without shifting its position.

He was told that the incrustation was a deposit of carbonate of lime, and the source of the lime was mentioned. But whence the brown colour, and the metallic nacreous lustre? If the substance were analogous to shell, it ought to contain animal matter; and whence could that be derived? It was necessary to trace the operations from the beginning.

The cotton cloth is brought to the bleach-field in the state in which it is taken from the weaver's loom. The first process is to steep it in water for several hours, after which it is immersed in cream of lime. This is made in the following manner: fresh-burned lime is slacked and passed through a fine sieve, and added to water in the proportion of 38 lbs. of dry lime to 1000 lbs. of cloth. The cloth is boiled in this liquor from four to six hours, the lime acting as an alkali; and it is used only from being considerably cheaper than potash or soda. After this boiling, the cloth is taken to the dash-wheel to be thoroughly cleared of the lime, which is effected by its being tossed about for ten minutes in clear water in the interior of one of the compartments into which the wheel is divided. Here, then, is the source of the calcareous matter of the incrustation; and we have the lime dissolved or suspended in the water in a state of extremely minute division, and from which it is deposited, most probably, by a partial evaporation. It is difficult to say whether the deposit takes place while the wheel is revolving, by the water being broken into a kind of spray, and so presenting a greater surface for evaporation, or during the night, when the wheel is still: some of the properties, to be afterwards described, render the latter supposition the most probable. But in whatever way it takes place, the operation is an exceedingly gradual one; for the wheel had been in constant use for ten years, and the coating in the interior did not exceed one tenth of an inch in thickness. It had been in operation about two years before any perceptible deposit showed itself in the inside; but it had not been going half a year before an incrustation began to be formed on the outside of the

* Specimens are deposited in the British Museum.

wheel. He remarked that the deposit was in greatest quantity around the orifice where the cloth is put in and taken out. The deposit in the interior, and which coated the whole surface of the compartment, was of a darker brown colour, and was as smooth and resplendent as a lining of highly polished bronze would have been. The high polish is no doubt partly produced by friction; and he observed that it was highest on that part of the outside nearest the opening.

So far we have *calcareous*, but no *animal*, matter; but in going a little further back in the history of the process to which the cotton had been subjected, before it came to the bleach-field, he discovered that animal matter might be contained in the incrustation. He learned that the cloth had been woven in power-looms; and on making inquiry as to the composition of the dressing or paste used to smooth and stiffen the warp before it is put into the loom, he was told that in the factory from whence the cloth had come, it is the practice to mix glue with the wheaten flour, generally in equal proportions by weight.

We have thus lime and gelatine, the same materials which are employed by a molluscous animal in the formation of its covering, and apparently in the same degree of minute division as that in which they are exuded from its mantle.

Chemical examination of the Substance.

1. *The external deposit.*—Exposed to the flame of a wax candle, it blackens, and gives out the usual smell of burning animal matter, the thin laminæ of which it is composed separating and curling up like films of horn; appearances similar to those exhibited by membranous shells when heated. When the flame is urged by the blowpipe, the laminæ separate still more, and are changed into an extremely light and brittle enamel, pure white, and having a pearly lustre. A fragment moistened on the back of the hand gives a sensation of heat, as quicklime does when so treated. The substance, when thrown into dilute muriatic acid, is entirely dissolved; the fluid is tinged yellow, and the effervescence produces a froth, like beer. When the acid is very much diluted, and a portion of the substance is suspended in it, the solution takes place gradually, minute flocculi of animal matter being separated, and floating in the fluid.

2. *The internal deposit.*—This is separable into extremely thin laminæ, and these, when in small fragments, are hardly distinguishable from scales of brown mica, showing also the most beautiful play of colours. The action of heat produces the same effect as on the external deposit, except that the separated laminæ are thinner. The action of muriatic acid is the same, but the yellow tinge is deeper, and the froth is more permanent, indicating a larger proportion of animal matter than in the other. The nacreous lustre is also much more conspicuous in this.

Mr. Gray, in his paper on the Structure of the Shells of Molluscous Animals, observes that the pearly or iridescent lustre appears to be confined to shells of the concretionary structure, which when broken exhibit a nearly uniform texture, but separate when heated into numerous thicker or thinner liminæ; and he adverts to the observation of Mr. Hatchett, that when they are digested in weak muriatic acid, the lime is dissolved, leaving a great number of thin plates of animal matter, which retain the original shape of the shell. He adds, "This variety of structure is found to constitute the whole shell of the *Anomiæ* and *Placunæ*, and to form the inner coat of those shells which have pearly insides, as the *Turbines, Haliotides*,

Uniones, &c., as well as the laminar portion of the *Pinnæ* and Mother-of-pearl shells."

Besides the laminated structure, there is, in the case of the Pinna and some other shells, a prismatic crystalline arrangement of the particles perpendicular to, and passing uninterruptedly through the laminæ; but I have not discovered such an arrangement in any portion of the incrustation, even when examined by the microscope.

A quantity of this singular deposit was sent to Sir David Brewster, and the following extracts from his letter present the main results of his investigation.

The substance in question does not resemble in its general aspect any natural or artificial production which I have seen. It is, generally speaking, brown where the surface is not iridescent, and in very thin plates: it is almost perfectly transparent, with a slight yellowish brown tinge like plates of glue or lac of the same thickness. The laminæ of which it is composed are sometimes separated by vacant spaces, at other times slightly coherent, but generally adhering to each other with a force greater than that of the laminæ of sulphate of lime or mica, and less than those of calcareous spar. When the adhering plates are separated, the separated surfaces are sometimes colourless, especially when these surfaces are corrugated or uneven; but they are almost always covered with an iridescent film of the most brilliant, and, generally, uniform tint, which exhibits all the variety of colours displayed by thin plates or polarizing laminæ.

The substance is of intermediate hardness between calcareous spar and sulphate of lime. It scratches the latter easily, and is not scratched by mother-of-pearl. Its specific gravity is shown in the following Table, which indicates its relation to analogous substances.

Calcareous spar . .	2.72
Oriental pearls . . .	2.68
New substance . .	2.44
Mother-of-pearl . . .	2.19
Oyster-shell . .	2.02

The new substance has the property of refracting light doubly, like most crystallized bodies; and, as in agate, mother-of-pearl, &c., one of the two images is perfectly distinct, while the other contains a considerable portion of nebulous light, varying with the thickness of the plate and the inclination of the refracted ray. It has one axis of double refraction, like calcareous spar, which is negative, as in that mineral, and, like it also, it gives a beautiful system of coloured rings by polarized light. The double refraction of the substance is very considerable, though greatly less than that of calcareous spar. A plate, one seventy-fifth of an inch thick, makes the first red ring of the system *eight* inches in diameter at a distance of twenty-six inches from the eye. The substance belongs to the rhombohedral system, and, as in the *Chaux carbonatée basée* of Hauy, the axis of the rhombohedron, or that of double refraction, is perpendicular to the surface of the thin plates. As mother-of-pearl has two axes of double refraction like aragonite, this new substance may be considered as having the same optical relation to calcareous spar that mother-of-pearl has to aragonite.

The images are nebulous, and not distinct as in calcareous spar. The reason is, that the substance is imperfectly crystallized like the agate, mother-of-pearl and other bodies in which the doubly refracting force separates the incident light into two oppositely polarized pencils, which are not perfectly equal and similar, but which differ from each other, sometimes in the

intensity of their light, sometimes in the distinctness of the image, sometimes in the nature or brightness of the colour, and sometimes in more than one of these characters. But though the new substance resembles the crystals above mentioned in giving dissimilar pencils of doubly refracted light, it stands unique among all bodies with which I am acquainted in possessing the extraordinary system of composite crystallization, in which an infinite number of crystals are disseminated equally in every possible azimuth through a larger crystalline plate, having their axes all inclined at the same angle to that of the larger plate, and producing similar phenomena in every direction, and through every portion of the plate; or we may describe this remarkable structure by saying that the minute elementary crystals form the surfaces of an infinite number of cones whose axes pass perpendicularly through every point of the larger plate.*

The iridescent phenomena exhibited by the new substance are extremely interesting, and I have been at much pains to examine them in a great number of specimens. The plates into which the substance is divisible have been formed in succession, and certain intervals of time have elapsed between their formation. In general, every two contiguous laminæ are separated by a thin iridescent film, varying from the three to the fifty millionth part of an inch in thickness, and producing all the various colours of thin plates which correspond to intermediate thicknesses. Between some of the laminæ no such film exists, probably in consequence of the interval of time between their formation being too short; and between others the film has been formed of unequal thickness, as happens in the oxidations upon steel when they are formed upon, or around, hard parts of the metal called *pins* by the workmen.

There can be no doubt that these iridescent films are formed when the dash-wheel is at rest during the night, and that when no film exists between two laminæ, an interval too short for its formation (arising perhaps from the stopping of the work during the day,) has elapsed during the drying or induration of the one lamina and the deposition of the other.

That these iridescent films are not thin films of the substance itself, may be inferred from the fact that light is reflected from their surfaces when they firmly adhere to the laminæ which inclose them. If, for example, we remove or raise up from a piece of mica a thin film which gives a bright green tint, and press it again into optical contact with the surface from which it was separated, it will then cease to exhibit any colour, because no light is reflected from its posterior surface; but if we press it into optical contact with another surface which has a different refractive power, its green colour will still be exhibited. It is owing to this cause that the colours of the oxidations on steel are so distinctly visible, and that the analogous oxidations are seen upon glass even before the film has begun to separate into coloured scales.

The iridescent films in the new substance possess another source of interest, in so far as they promise to throw a new light on the origin of the *incommunicable* colours of mother-of-pearl, which arise from the interior structure of the shell, and which cannot therefore be communicated to wax. These colours have frequently occupied my attention since the year 1814, when I described the phenomena of the colours communicable to wax;† but though I have devoted much time to the inquiry, I never could

* A rude idea of this structure is given by the beautiful cones, or rather pyramids of microscopic crystals of titanium which I have somewhere described as existing within the pyramids of many crystals of amethyst from the Brazils.

† Philosophical Transactions, 1814.

obtain a single result worthy of being communicated to the public. I took plates of mother-of-pearl that exhibited different bright colours through different parts of their surface, and by getting the mother-of-pearl ground away in different places by the seal-engraver's wheel, I endeavoured to discover the thicknesses at which the colours were produced, and the cause of the capricious variation of tints which arose from every inclination of the plate: but all my experiments were fruitless, and I abandoned the subject as beyond my reach. The phenomena, however, presented by the new substance seem to me to disclose the secret of which I was in quest. The layers of mother-of-pearl are deposited in succession like those which are formed upon the dash-wheel; and there can be no doubt that the animal whose mucous secretions form the shell that incloses it, rests occasionally from its toils, and affords a sufficient interval for the formation of an iridescent film upon the surface of the plate of shell which it daily deposits. Owing to the firm adhesion of the successive layers of the shell, we cannot, as in the more imperfectly formed new substance, separate each stratum in order to see the iridescent film upon their surfaces; but we can easily determine what phenomena would be produced if the layers of the new substance were as transparent as those of mother-of-pearl. If this were the case, we should see, both by reflected and transmitted light, the combined colours of all the iridescent films in the plate. When these films are numerous and flat, and of various thicknesses, the union of all their colours would form a pearly whiteness by reflected light, and when films of a particular colour predominate, both the reflected and the transmitted light would exhibit that prevailing colour: but if their surfaces are undulated as in mother-of-pearl, from the form of the shell and other causes,—if the iridescent films vary in thickness, and consequently in colour,—if they are wanting in some parts of the shell, and abound in others,—and if films of equal thicknesses occur in several laminæ in succession, and films of other thicknesses in other laminæ, which must necessarily take place from the varying and remitting action of the animal agent, then we shall have the very structure which is necessary for the production of the incommunicable colours of mother-of-pearl.

I have no doubt that this is the true cause of the phænomena which had so long perplexed me; and the results which I formerly obtained, though I could then attach no meaning to them, are in perfect unison with the preceding views. In order, however, to obtain something like an experimental confirmation of this opinion, I have examined the *fracture* of a mother-of-pearl shell where the laminæ have been all deposited with considerable regularity, and where their over-lying edges are exhibited, and I find distinct and positive proofs of the existence of iridescent films, sometimes green, and sometimes red in several successive strata. I am, &c.,

D. Brewster.

To Leonard Horner, Esq.

Lond. & Ed. Philos. Mag.

Chemical Composition of Asses' Milk.

From a memoir on the chemical composition of Asses' Milk, by E. Péligot, we learn that this milk differs from others in the considerable proportion of sugar of milk which it contains, and that to this we ought in all probability to attribute its medical properties.

The medium of 16 analyses gives in 100 parts of asses' milk,

Solid matter	9.53	Butter	1.29
Water	90.47	Sugar of milk	6.29
		Caseum	1.95
	100.		

The solid portion varied in different specimens from 7 to 11 per cent. of the milk.

The quality as well as quantity of the milk was found to vary materially with the food. Of four different kinds of provender, beets were found to yield a milk the richest in solid matter—next a mixture of Luzerne and oats, then potatoes, then carrots. The selected quantities of milk were with,

Beets - -	1.500 k.
Oats and Luzerne	1.500
Potatoes - -	1.250
Carrots -	1.000

Much depends also on *the time* at which the milk is drawn:—thus, milk taken at $1\frac{1}{2}$ hours, 6 hours and 24 hours after the previous milking, gave:

	after $1\frac{1}{2}$ hours.	after 6 hours.	after 24 hours.
Butter	1.55	1.40	1.23
Sugar of milk	6.65	6.40	6.33
Caseum	3.46	1.55	1.01
Solid matter	11.66	9.35	8.57
Water	88.34	90.65	91.43
	100.	100.	100.

As this last result is directly contrary to common opinion, the experiment was repeated after a lapse of six hours and of twelve hours from the previous milking, and found to coincide with the above.

But, on dividing the milk, obtained at the same milking, into three equal portions, they were found to contain,

	first part.	second part.	third part.
Butter	0.96	1.02	1.52
Sugar	6.50	6.48	6.45
Caseum	1.76	1.95	2.95
Solid matter	9.22	10.45	10.94

Thus proving the correctness of the common opinion, that the strippings afford the richest milk.

M. Péligot proved that by giving to an ass thirty grains of ioduret of potassium for six days, the milk contained iodine at the end of the period, as was evident by the action of starch upon it, and of a chloride. Ten grammes of common salt per day was detected by the taste of the milk, and by analysis. A chloride given, five grains per day to an ass, and twelve grains to a goat, was not discoverable in the milk.

The milk of an ass, to whom thirty grammes of bi-carbonate of soda was given for six days, was very alkaline even when first taken from the udder. This experiment was repeated fifteen times, whereas the milk of the ass has ordinarily an acid reaction. G.

Annales de Chemie et Phys.

Progress of Civil Engineering.

On the strain to which Lock Gates are subject. By PETER W. BARLOW, Civil Engineer.

Having of late been engaged in estimating the dimensions of timber required for Lock Gates, I have been led to the consideration of the different strains to which they are liable, and the results of my investigations having in some instances, been rather unexpected and interesting, I beg to lay them before the Institution of Civil Engineers, in the hope that they will prove of utility.

In England, of late years, lock gates of large dimensions have been constructed of an arched figure, with a view to increasing their strength; how far an advantage is gained by this construction, it is chiefly the object of the present paper to investigate. Previously, however, to entering into these inquiries, it will be necessary to explain the nature of the strains to which the common straight gate is exposed.

The best angle for the sally of lock gates made of straight timber is a subject which has already engaged the attention of some mathematical men, but I must observe, with respect to those investigations which I have had the means of examining, that they seem to be founded on data evidently incorrect. A common straight gate is exposed to two strains; one a transverse strain, produced by the weight of water at right angles to its surface, which is equal to half the weight applied in the middle; the other a strain in the direction of its length, produced by the pressure of the opposite gate upon its extremity.

This latter strain, if the salient angle was of 45°, or the gates stood at right angles to each other, would of course amount to half the weight on the opposite gate, so that at this angle a lock gate has, in addition to the transverse strain, an equal strain in the direction of its length.

Before we can arrive at the angle at which, with given dimensions of timber, the greatest strength will be given to a pair of gates, it becomes necessary to know the amount of transvere strain produced by the end pressure of the other gate; or in a beam loaded in the middle, the additional transverse strain, produced by a given degree of pressure applied at the ends. In order to ascertain this point precisely, it would be necessary to have a distinct set of experiments which would not only be difficult to execute, but very uncertain in their results; and as precision in this point is not necessary to the present question, I think by the examination of M. Girard's experiments, we may arrive at it sufficiently near for our purpose.

These experiments were made upon a large scale by order of the French government, and although there appears to be some irregularity in the results, I have no doubt that they are as correct as the uncertain nature of such inquiries will permit.

The following is an abstract of his experiments on the strength of oak baulks loaded at the end, and with the weight the same timbers would bear loaded in the middle, calculated by the rules given in Barlow's work on timber; by which a comparison can be made of the relative strength when subjected to a direct and transverse strain.

The timbers experimented upon by Girard were not in every case completely broken, but there is no doubt the weight they were subject to was very little short of that which would have completed the fracture.

Table I.

Abstract of GIRARD'S EXPERIMENTS *on the strength of timber loaded on the ends.*

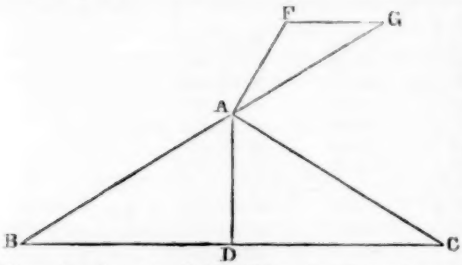
No. of experiment.	Dimensions of the Timber.			Weight in lbs. the beam bore applied to extremity.	Weight in lbs. the same beam would bear loaded transversely.	Ratio.	Remarks.
	Length.	Breadth.	Thickness.				
	feet.	inches.	inches.				
1	8	6.21	5.03	93616	8598	.092	
2	8	6.39	4.17	94018	6078	.064	Broken.
3	8	6.21	3.99	69165	5390	.078	
4	8	5.23	3.89	50526	4325	.085	Broken.
5	8.628	5.15	4.17	50608	4900	.097	Broken.
6	7.549	6.02	5.15	115359	9980	.087	
7	7.549	6.21	5.05	103799	9909	.095	
8	7.549	6.12	4.085	73095	6396	.087	Broken.
9	7.549	6.21	3.99	63177	6336	.100	Broken.
10	7.549	4.96	3.99	44857	4924	.109	
11	6.471	6.12	5.24	87494	12366	.141	
12	6.471	6.21	5.15	87481	12013	.136	
13	6.471	6.21	3.99	87079	7392	.085	
14	6.471	6.30	3.99	72823	7313	.100	Broken.
15	6.471	5.24	4.17	103622	6525	.063	
16	6.471	5.05	4.25	82261	6674	.081	
17	7.549	6.21	4.25	87443	7022	.080	
18	8.628	6.21	5.32	82332	9607	.116	Broken.
19	8.628	6.21	5.15	103863	8993	.087	
20	8.628	7.37	6.21	137966	15584	.113	
21	8.628	7.45	6.21	137866	15764	.114	
					Mean	.996	

It thus appears that the force required to break a timber in the direction of its length, is about ten times that which would break it if applied transversely at the middle; from which I infer that the strain in the direction of the gate produced by the pressure of the opposite one, is equal to an additional strain of one-tenth applied transversely. A difference exists in the comparison made in the preceding Table and in the case of lock gates, which it is necessary to make some remarks upon; viz., that a lock gate has a transverse pressure acting in addition to that produced by the other gate, so that the end pressure is exerted upon it after it is already deflected by a transverse strain, which is of course not the case in the comparison made in the Table. How far this may affect the question, or how much greater effect the compressive force may have in consequence of the beam being already deflected, it is very difficult to determine, but from an examination of the subject, I am induced to think that the deflection is so small as very slightly to increase the effect of the end pressure.

The amount of the effect will of course depend upon the degree of deflection the beam has sustained from the transverse pressure, and if it amounted to a quantity exceeding one-twentieth of the lengths (which would make the lever by which the end pressure acted exceed one-tenth of that by which the transverse strain acted,) a greater effect than one-tenth would be produced; but as the ordinary load which timber is expected to sustain, does not produce, at the utmost, a deflection exceeding one-hun-

dredth part of the lengths, I cannot conceive the transverse strain above named materially to alter the comparison, and I have accordingly, in the following investigation, assumed one-tenth as the amount of additional strain produced by the end pressure of the opposite gate.

It now becomes necessary to get an expression for the amount of the strains above mentioned at any angle of salience, which is arrived at in the following manner:—



Let AB, AC, represent the two gates, meeting at the point A; draw the line AD from the point A perpendicular to BC, and let BD, which represents half the breadth of the lock, $= l$, also let the pressure of water upon the length l of the gate be indicated by w and the angle ABD $= \varphi$.

Then the length of the AB and any angle φ will be expressed by $l \sec \varphi$

and the pressure upon it by $w \sec \varphi$

The transverse strain produced by this pressure on the centre of the beam at the same angle will be $\frac{1}{2} w \sec \varphi$

It now remains to find the amount of compression in the direction of the gate, produced by the opposite gate.

Let AF represent the force or tendency of the gate AC to turn upon the point C, which is of course equal to half the weight upon the gate AC,

or $= \frac{1}{2} w \sec \varphi$

The force may be resolved into AG, FG, the one GF is supported by an equal and opposite force in the gate AB, and the other will represent the force in the direction of the gate, the expression for which may be found as follows:

as sine $\angle$AGF : AF : : sine $\angle$AFG : AG.

$$\text{or sine } \varphi : \tfrac{1}{2} \text{ w sec } \varphi : : \cos \varphi : \tfrac{1}{2} w \sec \varphi \frac{\cos \varphi}{\text{sine } \varphi} = \tfrac{1}{2} \text{ cosec } \varphi$$

The whole amount of transverse strain at any angle φ will therefore be represented by the expression,

$$\tfrac{1}{2} w \sec \varphi + \tfrac{1}{20} w \text{ cosec } \varphi$$

from which we may readily obtain the angle at which the strain is a minimum, as follows:—

$$\sec + \varphi + \tfrac{1}{10} \text{ cosec } \varphi = \text{min.}$$

$$\text{or tan } \varphi \sec \varphi \, \text{d } \varphi - \tfrac{1}{10} \cot \varphi \text{ cosec } \varphi \, \text{d } \varphi = 0$$

$$\text{whence tan } {}^2\varphi = \tfrac{1}{10} \text{ cotan } \varphi$$

$$\text{and tan } {}^3\varphi = \tfrac{1}{10}$$

$$\tan \varphi = \sqrt[3]{\tfrac{1}{10}} = \tfrac{1}{10} \sqrt[3]{100} = .4641 = \tan \angle 24^\circ 54'$$

The salient angle of a pair of oak gates, when the strain is a minimum, is therefore 24° 54′.

In the question of the best angle for lock gates, it becomes necessary to consider that the length of the gate also varies as the secant of the angle φ. The angle 24° 54′ is therefore not that at which, with a given section of timber, the greatest strength will be obtained; for although the strain is the least at this angle, yet the gates, by their greater length, are less able to resist it than at some intermediate angle, when the strain is slightly increased.

The expression now becomes,

$$\sec^2\phi + \tfrac{1}{10}\sec\phi\,\mathrm{cosec}\,\phi = \text{min}$$

$$2\sec^2\phi\tan\phi\,d\phi + \tfrac{1}{10}(\tan\phi\sec\phi\,\mathrm{cosec}\,\phi - \cot\phi\,\mathrm{cosec}\,\phi\sec\phi) = 0$$

$$2\sec\phi\tan\phi + \tfrac{1}{10}\tan\phi\,\mathrm{cosec}\,\phi = \tfrac{1}{10}\,\mathrm{cotan}\,\phi\,\mathrm{cosec}\,\phi$$

$$2\sec\phi\tan^2\phi + \tfrac{1}{10}\tan^2\phi\,\mathrm{cosec}\,\phi = \tfrac{1}{10}\,\mathrm{cosec}\,\phi$$

from which the cubic equation, $\tan^3\phi + \tfrac{1}{20}\tan^2\phi = \tfrac{1}{20}$

This, being reduced, makes the tan = 25701, or the angle 19° 25′, at which a pair of lock gates should be situated, so as to have the greatest strength with a given section of timber.

Table 11

Length of Gate.	6 feet deep.		8 feet deep.		10 feet deep.		12 feet deep.		14 feet deep.		16 feet deep.		18 feet deep.		20 feet deep.	
feet.	Strain produced by the pressure upon 3 feet surface.	Dimensions of Sq. timber necessary to bear 3 times that strain.	Strain produced by the pressure upon 3 feet surface.	Dimensions of sq're timber necessary to bear 3 times that strain.	Strain produced by the pressure upon 3 feet surface.	Dimensions of sq're timber necessary to bear 3 times that strain.	Strain produced by the pressure upon 3 feet surface.	Dimensions of sq're timber necessary to bear 3 times that strain.	Strain produced by the pressure upon 3 feet surface.	Dimensions of sq're timber necessary to bear 3 times that strain.	Strain produced by the pressure upon 3 feet surface.	Dimensions of sq're timber necessary to bear 3 times that strain.	Strain produced by the pressure upon 3 feet surface.	Dimensions of sq're timber necessary to bear 3 times that strain.	Strain produced by the pressure upon 3 feet surface.	Dimensions of sq're timber necessary to bear 3 times that strain.
5	tons. .601	inches. 4.86	tons. 2.134	inches. 5.35	tons. 2.668	inches. 5.77	tons. 3.202	inches. 6.13	tons. 3.735	inches. 6.45	tons. 4.269	inches. 6.74	tons. 4.803	inches. 7.01	tons. 5.336	inches. 7.20
6	1.921	5.49	2.561	6.05	3.201	6.52	3.842	6.92	4.482	7.39	5.123	7.62	5.763	7.93	6.403	8.21
7	2.241	6.09	2.987	6.70	3.735	7.22	4.483	7.67	5 229	8.07	5.976	8.45	6.724	8.78	7.470	9.10
8	2.561	6.66	3.414	7.32	4.268	7.89	5.123	8.39	5.976	8.83	6.831	9.23	7.685	9.60	8.538	9.94
9	2.882	7.20	3.841	7.92	4.802	8.54	5.763	9 07	6.723	9.55	7.684	9.98	8.645	10.38	9.600	10.75
10	3.202	7.72	4.268	8.50	5.336	9.16	6.404	9.73	7.470	10.24	8.538	10.71	9.606	11.14	10.672	11.54
11	3.522	8 23	4.695	9.06	5.869	9.76	7.044	10.37	8.217	10.92	9.392	11.41	10 566	11.87	11.739	12.30
12	3 842	8.72	5.122	9.60	6.402	10.34	7.684	10.98	8.964	11.57	10.246	12.10	11.526	12.58	12.806	13.03
13	4.162	9.20	5.548	10.12	6.937	10.90	8 325	11.59	9.711	12.20	11.099	12.76	12.488	13.27	13.874	13.74
14	4.482	9.67	5.974	10.64	7.470	11.46	8.966	12.18	10.458	12.82	11 952	13.40	13.448	13.94	14.940	14.44
15	4.803	10.12	6.402	11.14	8.064	12.00	9.606	12.75	11.205	13.42	12.807	14.03	14.409	14.55	16.008	15.12
16	5.122	10.56	6.828	11.63	8.536	12.53	10.246	13.31	11.952	14.01	13.662	14.65	15.370	15.24	17.076	15.78
17	5.443	11.01	7.255	12.11	9.071	13.05	10.887	13.86	12.699	14.60	14.514	15.26	16.330	15.86	18.142	16.43
18	5766	11.43	7.683	12.58	9.603	13.55	11.526	14.40	13.446	15.16	15.360	15.85	17.289	16.48	19.209	17.07
19	6.083	11.85	8.109	13.04	10.138	14 04	12.167	14.93	14.195	15.72	16.222	16.43	18.251	17.09	20.277	17.70
20	6.404	12.26	8.556	13.49	10.672	14.54	12.808	15.45	14.940	16.26	17.076	17.00	19.212	17.68	21.344	18.31

In making use of the above Table, for obtaining the necessary dimensions of the lower timbers, it has to be considered that a great support is afforded by the sill of the Gate, which will of course permit with safety the use of less timber than the Table will give. The influence of this support cannot, however, extend beyond the second timber from the bottom, as the deflection of the planking will allow the whole of the pressure to be effective.

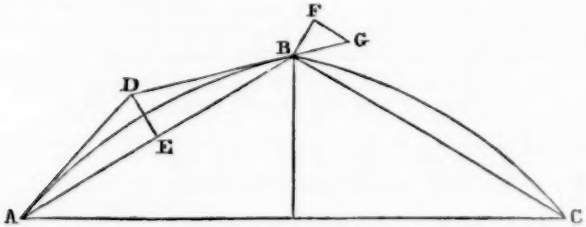
Having obtained, in a manner I hope satisfactory, the angle of greatest strength for gates of straight timber, I conclude this part of my paper with a Table of the necessary dimensions of oak timber for lock gates varying from 6 to 20 feet in length, and from 8 to 20 feet in depth, which I believe are the limits of the dimensions of gates of this construction.

The first column in each division of the Table gives the amount of transverse strain produced by the pressure of water upon three feet depth of surface, at an angle of 19° 25′; and the second column the dimensions of square oak timber necessary to bear three times that strain.

Curved Lock Gates.

In locks of large dimensions in this country, a curved figure is given to the gates, so that when united they resemble a Gothic arch; this figure, by giving greater strength, permits a reduction to be made in the dimensions of the timber, and the gates are thereby rendered lighter, and more readily movable. The degree of curvature which will give the greatest strength, and the necessary dimensions of the timber in different sized locks, are of course points of considerable importance, not only on the score of economy, but from the greater degree of lightness that may be thus obtained; the opening and shutting can be performed with greater ease, and consequently a greater number of ships can be permitted to pass in a given time.

In order to estimate the degree of curvature which will give the greatest strength, it is first necessary to consider the nature and amount of the strains to which the gothic shape gives rise, we may then perceive what variations, with respect to the degree of curvature and amount of salience, will tend to increase the strength, or vice versa.



Let AB, BC represent two gates meeting in the point B, and let the angle of salience, BAC, be equal to ϕ, also the angle DBE of a tangent to the curve of the gate, with the cord BA $= \theta$, and the pressure of water upon each gate $= w$. The gate AB, being loaded equally all over, will exert a pressure in the direction of the tangent, to the extremity of the gate, which will be represented by the line DB, (the perpendicular DE being equal to $\frac{1}{2}w$,) or equal $\frac{1}{2}w$ cosec θ.

This force is partly resisted by the compressive force of the opposite gate, which now, instead of adding to the transverse strain, as in the straight gates, is the means of diminishing it in proportion as it counteracts or destroys the tangential force DB. In order therefore to estimate the amount of strain, it becomes necessary to get an expression for this force, which may be done as follows.

Let BF represent the force acting at right angles to the extremity of the gate BC, tending to turn it upon the point C, which is of course equal to half the pressure of water. Resolving this into the direction of the tangent of the curve AB, by drawing FG parallel to BC, and producing DB, we

obtain the line BG, which represents the compressive force of the gate BC in the direction of the tangent DB, and which is equal $\frac{1}{2} w \operatorname{cosec} (2\phi - \theta)$.

As the diminution of strain owing to this force is, in proportion it destroys the tangential force DB, the amount of the transverse strain at any angle, ϕ and θ may be found by the following proportion:

$$\tfrac{1}{2} w \operatorname{cosec} \theta : \tfrac{1}{2} w \left\{ \operatorname{cosec} \phi - \operatorname{cosec} (2\theta -) \right\} : : \tfrac{1}{2} w : x$$

$$\text{Or, } x = \frac{\frac{1}{2} w \left\{ \operatorname{cosec} \theta - \operatorname{cosec} (2\phi - \theta) \right\}}{\operatorname{cosec} \theta}$$

$$= \tfrac{1}{2} w \left\{ 1 - \frac{\operatorname{cosec} (2\phi - \theta}{\operatorname{cosec} \theta} \right\}$$

$$= \tfrac{1}{2} w \left\{ 1 - \frac{\operatorname{sine} \theta}{\operatorname{sine} (2\phi - \theta)} \right\}$$

which is the true expression of the transverse strain or weight applied transversely in the middle of the length, which would have equal effect in breaking the timber.

It will at once be seen that when the united gates form a complete arch, that is, when the angles ϕ and θ become equal, the expression vanishes, the tangential force being then resisted by an equal compressive force in the opposite gate.

In this position, therefore, if the curve was mathematically true, the strain perfectly equal and regular, and the material also of an uniform density, the loading the arch would have no other effect than that of direct compression in the direction of the fibres, a description of strain which timber possesses great power to resist, as appears from the experiments of Girard. In practice this cannot, however, take place; the curve can neither be perfectly true nor the density of the material uniform, either of which defects would lead to a transverse strain, which, if sufficient weight was put on, would ultimately destroy the gate. In the former case, the flatter parts of the curve would naturally have a transverse strain upon the bottom fibres, from the abutments or terminations of it not being resisted with an equal degree of compressive force; the fibres would in consequence in some measure yield, and the relative position of the gates at the point of meeting would be changed, so as not to touch equally throughout; an increased compression would be brought upon particular fibres, which must of course yield, and the evil would continue to increase until fracture ultimately took place. In a similar manner, an irregular density of the material, by causing a yielding in some parts more than others, would bring on a change of shape which would ultimately produce the same results.

It therefore appears that in either case the cause which ultimately leads to fracture is the transverse strain produced from the irregularity of the curve, brought on by circumstances which cannot be controlled. Hence the nearer the curve can be preserved in the true figure of an arc of a circle, the greater the strength of the gates.

It has however to be considered that the arch is not composed of one complete timber, but that the fibres are disunited at the point of meeting, and consequently if that part from any cause should become flattened there are no fibres to resist the transverse strain thus produced; and as the flattening of this part of the arch is an effect which might probably arise from any yielding of the abutments, or wear of the heel posts in the hollow quoin, this would evidently be the weakest part of the curve. It therefore becomes necessary to deviate in a small degree from the true curve of the

arch, by giving the gates greater length, and causing them to meet at a point a short distance from the curve, or in fact rendering them slightly Gothic; but as the security to the point is obtained at the expense of a constant transverse strain upon each of the gates, the deviation from the true arched figure should be as little as possible, consistently with the object in view, and by no means so great as is commonly employed in lock gates: I should think a deviation of one foot or eighteen inches quite sufficient for the purpose of locks of from forty to fifty feet wide.

Proposed Curve.

General Remarks.

It was my intention to have concluded the preceding part of the article with a table of the requisite dimensions of timber for gates of different sizes, both of the curves commonly employed, and of those which I should recommend; I find, however, that these calculations would require a greater length of time than I can at present devote to the subject, and I therefore conclude with a few general remarks on the results arrived at.

In the first place, with respect to the proper angle of straight gates, this being a subject naturally calculated to excite the propensities of the mathematician to set his maxima and minima to work, a great number of solutions to the problem have been given; but I must remark, with every respect for that useful class of men, that they are frequently too anxious to commence investigations without sufficient data, and consequently arrive at results totally incorrect, which has certainly been the case in those investigations I have had an opportunity of examining on the subject.

It seems to me perfectly impossible to arrive at correct results, without first ascertaining the amount of transverse strain produced by the end pressure, which does not seem to have been done before; but having obtained this from Girard's experiments to be one-tenth of the effect of an equal weight in the middle of the length, I have little doubt that the angle 19° 25′ would be found, by experiments, to be very nearly that in which the greatest strength would be obtained with a given quantity of timber.

The angle commonly adopted in this country, is considerably more than 19° 25′, amounting generally to between 30 and 40 degrees, which is said to be preferred from the direction of the thrust being met by a large quantity of brickwork. I cannot, however, conceive this to be a matter of much importance, particularly as there are locks on the continent, of large dimensions, where the angle is considerably less, which have stood perfectly well. The angle of the celebrated sea-lock of Muyden is only 16° 30′, and the ancient lock of Sparendam, which was built in 1568, and has stood many storms without injury, has a sally of not more than one-sixteenth:—the angle ought certainly to be in some measure guided by the circumstances in which the gate is placed; at the same time, I consider the angle commonly made use of in England, to be decidedly larger than necessary, and a useless weight of material employed, which increases one of the evils of canal navigation,—the time consumed in passing the locks.

The employment of curved timber is undoubtedly advantageous, but its application is evidently made upon no fixed principles, as may be seen from

the differences of the curves which have been adopted; some being so great as to very nearly approach the figure I have pointed out as the best, while others are so exceedingly flat that they possess little advantage over the straight gate.

To illustrate these differences in wooden gates, I have represented, in the accompanying drawing, the curves employed in the gates of the St. Katharine's, London, and West India Docks. The dimensions are as follows:—

St. Katharine's Docks.

Width of the lock 45 feet. Projection 11 feet.
Radius of the gate 117

Consequently the angle $\phi = 29° 16'$, and $\theta = 6° 8'$.

London Docks.

Width of the lock 40 feet. Projection 9 feet.
Radius of the gate 50

Angle $\phi = 23° 35'$ and $\theta = 13° 54'$

West India Docks.

Width of the lock 45 feet. Projection 10 feet.
Radius of the gate 120

Angle $\phi = 26° 24'$, and θ 5° 53'.

With the aid of the preceding formulæ I have calculated the amount of transverse strain in each case, (half the pressure of water upon one gate being unity,) and the same, if they were of straight timber, having an equal salient angle. These formulæ are arranged in the following Table.

In order to make the comparison of the straight and curved gate more direct, there is also added a column of the amount of transverse strain on the latter, that of the straight gate being unity.

The fourth column illustrates the reduction of the dimensions of square timber which may be permitted owing to the diminished strain.

Table III.

Gate.	Transverse strain $\frac{1}{2}w$ being unity.	Transverse strain of straight timber having the same salient angle, $\frac{1}{2}w$ being unity.	Transverse strain, that on the straight gate being unity.	Dimensions of timber having equal strength that on the straight gate being unity.
At St. Katharine's Docks,	.86	1.178	.73	.900
London Docks,	.56	1.229	.45	.766
West India Docks,	.86	1.201	.72	.806

It thus appears that considerable advantage is gained in each case from the curvature, but that in the London Docks, from the radius being less, and the two gates in consequence approaching nearer the curve of a complete arch, the advantage is much greater, and the transverse strain in consequence reduced to less than half that of straight gates having the same salient angle.

The difficulty of obtaining timber of sufficient curvature has been urged as a reason for the flatness of the curves employed in wooden gates; this is certainly a consideration which must be attended to, but as similar curves are employed when the material made use of is cast iron, I cannot, conceive this to be a point which has materially influenced the choice of the figure.

In the accompanying drawings are given curves of the gates of the Caledonian Canal, the Dundee Docks and Sheerness Basin, which are of cast iron: they will be found to differ very materially from each other, being in one instance nearly as flat as in the West India and St. Katharine's Docks.

The following are the dimensions:—

Caledonian Canal.

Width of the lock 40 feet. Amount of projection 10 feet.
Radius of curvature 75 "
Angle of sally $\varphi = 30°$, and $\theta = 8° 3'$.

Dundee Dry Docks.

Width of entrance 40 feet. Amount of projection 7 feet 6 inches.
Radius of curvature 67 "
Angle of sally $\varphi = 22° 2'$, and $\theta = 9° 12'$.

Sheerness Basin.

Width of entrance 58 feet. Amount of projection 12 feet 6 inches
Radius of curvature 55 "

Angle $\varphi = 24° 5'$, and $\theta = 16° 55$.

To make a comparison of these curves, I have calculated a Table, as in the case of the wooden gates, containing the amount of the transverse strain which straight gates would have under similar circumstances.

The same formula is employed for this purpose as for the wooden gates, which may not be strictly true with cast iron; but I should not conceive the difference to be sufficient materially to affect the comparison.

Gate.	Transverse strain, half the pressure of water being unity.	Transverse strain of a straight gate, with the same salient angle.	Transverse strain, that of the straight gate being unity.	Dimension of iron of similar section with the straight gate, that of the latter being unity.
At Caledonian Canal	.82	1.173	.700	.887
Dundee Docks	.72	1.247	.58	.834
Sheerness Basin	.44	1.215	.35	.704

It thus appears that in the gates of the Caledonian Canal the transverse strain is nearly as great as in the West India and St. Katharine's Docks. In those of the Dundee Docks and Sheerness Basin, a considerable improvement is made, particularly in the latter, where the strain amounts to little more than one-third of that which the straight gates would have in the same situation; but I conceive that by slightly diminishing the salient angle, and increasing the curvature of the gates, the advantage might be carried still further,—the same strength produced by less weight of material, and a lightness given which would greatly facilitate the passing and repassing of vessels.

Mechanics' Register.

Deepest Mine in Great Britain.

Our readers may perhaps recollect that, some time ago, a coal-pit said to be the deepest in Great Britain, was sunk at Monkwearmouth, to the depth of 264 fathoms, or 1584 feet below the surface;* and that in November, 1834, Professor Phillips of York, along with a number of other scientific persons, descended the pit, and made a series of very interesting observations on the variations of the barometer and thermometer in the course of their descent and ascent. The temperature, by these observations, in-

* There are more shafts than one at the consolidated mines in Cornwall, which are nearly 300 fathoms in depth or 1800 feet. G.

creased in proportion to the depth, and a thermometer sunk into a hole, drilled to the depth of two and a half feet into the floor of the workings, from which hole the air was carefully excluded, after remaining in that position forty-eight hours, stood at 71.2. Since the date of Professor Phillips' visit, the enterprising owners have sunk it still deeper, and the average temperature has increased to seventy degrees, a degree of heat which makes it difficult for the men to work beyond six hours at a time.* In addition to this inconvenience, a species of fly, about an inch long, has appeared, by the bite of which both men and horses are much annoyed. Mining Journal.

Electrical Telegraph.

During the month of June last year (1836,) in a course of lectures delivered at King's College, London, Professor Wheatstone repeated his experiments on the velocity of Electricity, which were published in the *Philosophical Transactions* for 1834, but with an insulated circuit of copper-wire, the length of which was now increased to nearly four miles; the thickness of the wire was $\frac{1}{16}$ of an inch. When machine-electricity was employed, an electrometer placed on any point of the circuit diverged, and wherever the continuity of the circuit was broken, very bright sparks were visible. With a voltaic battery, or with a magneto-electric machine, water was decomposed, the needle of a galvanometer deflected, &c., in the middle of the circuit. Prof. Wheatstone gave a sketch of the means by which he proposes to convert his apparatus into an electrical telegraph, which, by the aid of a few finger-stops, will instantaneously, and distinctly, convey communications between the most distant points, These experiments are, we understand, still in progress, and the apparatus, as it is at present constructed, is capable of conveying thirty simple signals, which, combined in various manners, will be fully sufficient for the purposes of telegraphic communication. Mag. Pop. Sci.

Bronze Coinage proposed in France.

"The question of a new coinage in France, in lieu of the present one of copper, billon, &c., is under consideration. Nothing can be much worse than the existing one; for besides its low pretensions in relation to art, it is of all sizes, weights, designs, and alloys. The new one is proposed to be of bronze, in harmony with the decimal system of weights and measures, less heavy and embarrassing, not easily falsified, and executed in the highest style of excellence. The latter condition well very much increase the difficulty of counterfeiting it."—*Annuaire*, 1837. Ibid.

Proportional Value of the present coined Metals in France.

The value of Gold in proportion to that of Silver is as 15.5 to 1

Gold	.	to	.	Billon†,	62.0 to 1
Gold	. .	to	. .	Copper,	620.0 to 1
Silver	.	to	.	Billon,	4.0 to 1
Silver	. .	to	. .	Copper,	40.0 to 1
Billon	.	to	.	Copper,	10.0 to 1

Ibid.

* At the bottom of Wolf's shaft, at the consolidated mines, the temperature is said to have been as high as 96°. G.

† An alloy of silver and copper.

Removing Stains from Prints, &c.

We have received the following communication from an intelligent correspondent:—"I have by accident discovered what might be useful to some of your readers to know—that the clear solution of chloride of lime, diluted with twice its bulk of water, will effectually and expeditiously remove stains from prints and printed paper. Instead of the ordinary process, which is expensive and tedious, first soak the print in clear water, till it lies smooth; then remove it into a dish, large enough to hold it flat, filled with the solution diluted as above:—the stains will disappear in a few minutes, when again soak the print in clear water, to free it from the chloride of lime, and then dry it between sheets of blotting-paper. By this process I have bleached twelve prints, and letter-press belonging to an expensive book, which had been damaged by rain and sea water."—*West of England Conservative.* Mech. Mag.

Award of the Copley Medal to Berzelius.

The Council of the Royal Society have awarded a Copley Medal to Baron Berzelius, for his application of the Doctrine of Definite Proportions in Determining the Constitution of Minerals. To the labours of this distinguished chemist, science is indebted for many of the facts by which the Laws of Definite Union were established. As early as 1807, soon after Dalton and Gay-Lussac had made known their views on this vital branch of modern chemistry, Berzelius commenced an elaborate examination on the proportions in which the elements of compound bodies are united, beginning with the salts, and subsequently extending his researches to all other departments of this science, as well to the products of organized existences as to those of the mineral world. The first part of the inquiry appeared in a series of essays in the Afhandlingar i Fysik, Kemi, och Mineralogie, t. iii. iv. v. and vi., as also in the Memoirs of the Academy of Sciences of Stockholm, for the year 1813. Since that period he has almost constantly been more or less occupied with researches bearing on, or illustrative of, the same subject. His numerous analyses of minerals enabled him at once to elucidate their nature through the light derived from the laws of definite combination, and at the same time to supply in the composition of minerals a splendid confirmation of the universality of those laws. It is for this branch of his inquiry that the Copley Medal has been awarded. Lon. & Ed. Phil. Mag.

Extraordinary Speed.

On Thursday, the 15th inst., a large and powerful locomotive engine, built by Mr. Timothy Hackworth, of New Shildon, for the Emperor of Russia, was shipped on board the *Barbara*, at Middlesbro'. This engine is constructed on an improved principle, and finished in the best manner. She has been tried on the premises, and propelled at the rate of seventy-two miles per hour! It is said that this machine, and the similar one built at Newcastle, will, on their arrival at St. Petersburgh, have cost the Emperor upwards of 2000*l.* each. Who, a few years ago, would have dreamed of the exportation of machinery from the river Tees? This engine is for traveling on the railroad from St. Petersburgh to Pawlowski, where stands one of the country palaces of his Imperial Majesty. Mining Jour.

LUNAR OCCULTATIONS FOR JUNE, 1837.

Day.	H'r.	Min.			N.	V.
16	10	52	Im.	σ Scorpii. 4,	35	40
16	11	57	Em.		287	304
17	9	48	Im.	y Ophiuchi, 6,	26	6
17	10	38	Em.		302	292

Meteorological Observations for February, 1837.

Moon.	Days	Therm. Sun rise	Therm. 2 P.M.	Barometer. Sun rise	Barometer. 2 P.M.	Wind. Direction.	Wind. Force.	Water fallen in rain.	State of the weather, and Remarks.
				Inches	Inches			Inches.	
☽	1	36°	43°	29.64	29.60	W.	Moderate.		Cloudy—clear.
	2	29	31	60	70	W.	Blustering.		Cloudy—clear.
	3	30	37	80	90	W.	do.		Clear—clear.
	4	35	37	90	90	E.W.	Moderate.		Cloudy—lightly cloudy.
	5	31	40	30.10	30.10	E.			Cloudy—clear.
	6	30	40	65	60	NW.W.			Cloudy—clear.
	7	30	36	29.94	29.75	SW.			Fog—do.
	8	39	39	54	90	NE.	Blustering.	.15	Cloudy—do.—snow in night.
	9	34	38	63	80	NE.	Moderate.		Clear—do.
	10	34	36	83	80	NE.	do.		Partially cloudy—do—do.
	11	34	34	93	30.00	W.	do.		Hazy—clear—flurry of snow.
	12	32	41	86	29.70	W.			Clear do.
	13	14	16	65	30.10	W.SW.	Blustering		Clear—do.
	14	9	28	7ᵗʰ	70	SE.	Moderate.		Rain—foggy.
	15	32	41	60	60	E.	do.	1.00	Rain—do.
	16	33	37	60	60	W.	do.	.10	Snow—cloudy.
	17	32	37	30.15	46	W.	do.		Clear—do.
	18	31	36	30	30	W.	do.		Clear—do.
	19	10	17	20	20	E.S.	do.		Cloudy—lightly cloudy.
	20	17	36	29.91	29.90	W.	do.		Partially cloudy—do. do.
	21	26	45	60	65	NW.	do.		Clear—lightly cloudy.
	22	28	43	30.10	30.05	E.	do.	1.00	Rain—fog.
☉	23	29	44	29.73	29.35	W	do.		Cloudy—flying clouds.
	24	36	37	33	50	NW.	do.		Clear—clear.
	25	31	43	95	30.02	SE.	do.		Cloudy—do.
	26	35	44	73	29.39	W.	do.	.32	Cloudy—rain—snow.
	27	34	42	70	64	W.	do.		Flying clouds—do. do.
	28	18	33	40	64	W.	Blustering.		
	Mean	26.96	34.96	29.69	29.81			2.57	

Thermometer.			Barometer.	
Maximum height during the month	45. on 20th.		30.66 on	4th.
Minimum	do.	9 on 14th.	29.20 on	17th.
Mean	do.	30.96.	29.45.	